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CONTENTS

TRANSIT GAS PIPELINE COMPRESSORS, OTHER UNUSUAL HEAT SOURCES OUTLINED

Prague MECHANIZACE ZEMEDELSTVI in Slovak No 3, 83 pp 106-110

[Article by Eng Vladimir Kujan, Design Institute of Land Economy, Bratislava: "Waste Heat from Gas Pipeline Compressor Stations"]

[Text] In this part of the article, Eng Kujan discusses the use of unusual and secondary sources of energy in agriculture. The article describes the possibilities for utilizing the biological heat from milk, biogas and waste heat from transit gas pipelines. These sources are already used in some agricultural enterprizes or construction of such facilities is planned.

Four compressor stations [KS] have been built so far in the SSR along the transit gas pipeline in the following areas: KS-01 Velke Kapusany facility in Trebisov District, KS-02 Jablonov nad Turnou facility in Roznava District, KS-03 Velke Zlievce facility, Velky Krtis District, KS-04 Ivanka pri Nitre facility, Nitra District.

The term "waste heat from a gas pipeline compressor station" [KS-TP] means heat obtained from gas turbine exhausts, transferred to the circulating water of hot-water "combustion products-water" exchangers. A hot water exchanger with a power output of 6.45 MW (5.55 Gcal/h [Giga calories per hour]) is installed in the turbine exhaust passage and permits continuous regulation from 7 to 100 percent. Hot water from the "combustion products-water" exchanger circulates through hot water pipes in the receiving station situated in the greenhouse area, from where it passes through a heat conductor into production structures (greenhouses, low-temperature drying houses, operational buildings etc.) and then returns to the exchanger through return-water pipes. The entire system is designed as a regulated primary circuit with temperature regulation in both the exchanger and the receiving station.

Greenhouse farms are the first stage in the construction of agricultural-food complexes based on the use of waste heat. Table 1 shows the amount of waste heat available in individual plants at the beginning of operations, according to an intersector agreement.

Table 1. Amount of Waste Heat in Compressor Stations (MW)

Compressor Station	Period of Beginning of Offtake		
	1982/83	1983/84	1984/85
KS-01 Velke Kapusany	20.9	23.2	29.0
KS-02 Jablonov nad Turnou	18.6	20.9	23.9
KS-03 Velke Zlievce	9.3	17.4	19.8
KS-04 Ivanka pri Nitre	9.3	17.4	19.8

The present situation in construction of first-stage agricultural-food complexes is as follows:

KS-01 Velke Kapusany

Construction of a 2.5 hectare complex of greenhouses was begun in 1979. Engineering network auxiliary buildings and the main building of the receiving station are part of the complex. The operational use of waste heat will begin in the 1982/83 heating season, i.e., in the fourth quarter of 1982.

KS-02 Jablonov nad Turnou

Construction of a 3.0 hectare greenhouse complex began on 1978. The first phase consists of production structures proper, auxiliary engineering network and the receiving waste heat station. The operational use of waste heat should begin on the 1982/83 heating season, i.e., in the fourth quarter of 1982.

KS-03 Velke Zlievce

Construction of a 2.0 hectare greenhouse complex began in 1980. The first stage of the construction consists of the greenhouses proper and additional structures, including the engineering network. The operational use of waste heat will begin in the 1983/84 heating season, i.e., in the fourth quarter of 1983.

KS-04 Ivanka pri Nitre

Construction of a 2.5 hectares greenhouse complex began in 1980. The complex consists of production and auxiliary structures and engineering network. The first stage of the construction will be completed and operation will begin in the 1982/83 heating season, i.e., in the fourth quarter of 1982.

Proposal of Short-Term Measures

The document proposes that the first stages of complexes be completed and waste heat used during 1982-83. To achieve this, it is necessary to shorten delivery terms of technological equipment for the receiving stations. Further, it is necessary to require the main supplier of the Heat II, GRT STS Rovinka, to complete the technological part in time for operations to begin by the deadline.

Also, development of the "low-temperature dryer" in the Vzduchotechnika (Air Technology) Nove Mesto nad Vahom, must be completed for testing at KS-04 in Ivanka pri Nitre during the second and third quarters of 1984. Designs of substitutional heat sources for individual OT-KS-TP greenhouse complexes in the SSR should be prepared and their construction should begin. The UKS-01-KS-04 greenhouse area must be extended to 6.0 hectares.

Proposal of Long-Term Measures

This proposal is based on the assumption that designs for large cooling units with an absorptive ammonia-water cooling systems will be completed allowing waste heat to be used for air-conditioned food and fruit storehouses this summer. Designs must be prepared for large air-conditioned potato storehouses and suitable production technology. The development should be directed to the problems of heating open land areas, treatment of liquid manure, construction of large composting facilities and water tanks, and finally, to the accumulation of heat in so-called lake reservoirs (see design by docent Ibl of the Czech Institute of Technology). Spacious greenhouses with long cross-bars should be designed, permitting the use of large machinery for soil cultivation.

Research Tasks

Research should be directed to designing suitable technologies in the area of drying and absorptive cooling equipment, to the problems of heating open land areas and antifreeze protection and to the possibilities of hydroponic growing of certain kinds of vegetables in greenhouses, drying green grain and sublimative drying of food products (milk, fruit, juices, etc.).

Requirements for the Manufacturers

We require manufacturers to complete development of universal low-temperature dryers (for volume fodder, vegetables and fruit) and begin to manufacture heat pumps and absorptive systems for air-conditioned warehouses with controlled atmosphere.

Biological Heat of Milk

Intensified methods of cattle breeding, namely cows, have been recently introduced in our country and abroad. This situation permits economizing in labor and energy requirements, since we obtain several thousand liters of milk at one time. Milk is usually prevented from spoiling (loss of quality) by cooling it immediately to a temperature of about 4°C from its original temperature of 38°C. The heat removed from the milk during the cooling process is not used at present and escapes into the air. Given the present fuel-energy situation, both manufacturers and users of cooling systems should consider using this liberated waste heat.

Survey of the Present Conditions in the CSSR

No equipment for utilizing waste heat released during the cooling of milk is yet manufactured in the CSSR. It is true that several pieces of equipment using waste heat exist, however, all of them have been built by amateurs from available materials and based on equipment manufactured in connection with different purposes.

Tests on some of this equipment are now being completed. Auxiliary equipment for milk-cooling units which use waste heat to heat service water up to 55° are being prepared for manufacture in 1982. TOPOS Sluknov should be one of the future manufacturers of this auxiliary equipment using the 827 01 heat exchanger, another manufacturer should be STS Brno, Dolni Herspice, which will manufacture this equipment uisng the ZK 8-017 instantaneous water heater.

The TOPOS Sluknov's manufacturing department is considering the production of a so-called closed system which employs a heat exchanger situated directly in a warm service water storage tank. The removal of water and additional filling of storage tanks with fresh water is achieved by hydrostatic pressure in the water piping.

The manufacturer, STS Brno-Dolni Herspice, is considering the production of a so-called open system in which a flow water exchanger (pipe-in-pipe) is situated outside the storage service water tank and the additional filling of the storage tank, (which is open and directly interfaces with the outside air) is achieved by hydrostatic pressure in the water piping only when water in the inverse current instantaneous heater is heated to about 55°C. The temperature is measured and a thermostat opens or closes the flow of warm service water into the open storage tank. Warm service water can be removed only using a pump (Table 2). The dimensions of the casing of the ZK 8-017 inverse current heater are 730x900x300 mm.

Table 2. Technical parameters of Equipment in TOPOS Sluknov and STS Brno, Dolni Herspice

Equipment Name	TOPOS Sluknov	STS Brno Dolni Herspice
	Heat Exchanger	Instantaneous Anticurrent Water Heater
Type	827.0	ZK 8-017
Size: Length, Width, Height (meters)	0.900x2	2x1x1 1x1x2
Weight (kg)	240	not given
Inner Volume (cubic decimeters)	750	2,000
Coolant	CCl_2F_2 $CHClF_2$	CCl_2F_2 $CHCIF_2$
Attached Piping		
-- Water	Js 3/4	JS 1/2
-- Coolant	22/1.5	Cu 16 and 12
Operational Voltage (V)	380/320	380/220
Maximum Operational Overpressure (MPa)	0.6	0.6
Service Life (Years)	30	20
Cost of Complete Equipment, Including Installation (Kcs)	27,000	20,000

Short-Term Measures

Milk Production in the SSR During the Seventh 5-Year Plan

The yearly milk production proposed for the Seventh 5-Year Plan is shown in Table 3.

Table 3. Annual Production of Milk According to Seventh 5-Year Plan Proposal

	Year				
	1981	1982	1983	1984	1985
Milk Production (Millions Liters per Year)	1,553	1,571	1,599	1,627	1,657

Achieving Development and Line Production of Equipment

Development and line manufacture of equipment for the utilization of waste heat in cooling milk should primarily be achieved by the manufacturers of milk-cooling equipment, since they have the best and most systematic experience in these problems.

Supplies, Assembly and Putting the Equipment Into Operation

Both the cooling system and the auxiliary equipment for using waste heat should be supplied, assembled and put into operation by the manufacturers or organizations trained and commissioned by them and they should also provide servicing of the equipment. From 1983 on, the milk-cooling system should not leave the gates of the factory without auxiliary equipment for using waste heat, primarily for heating service water, i.e., such as a water-water heat pump. If we realize that by using this equipment we can receive 0.54 to 0.66 liters of warm service water at a temperature of 50 to 55°C from 1 liter of fresh milk, we can then easily calculate how much electrical energy we can save each year by using waste heat from cooling for heating water. Table 4 shows us savings achieved while using waste heat to heat water from +10 to +50°C

Since the SSR Ministry of Food Industry and Supply [MPVz] operates about 430 large-capacity milk-cooling systems and if we assume the installation cost of such auxiliary equipment to be about Kcs 30,000 each, then the necessary investment would be approximately Kcs 13 million.

Possibilities of Using Generated Heat

The use of waste heat from milk-cooling equipment is most suitable to heat service water used for specific industrial purposes, such as washing cattle or other hygienic purposes. The amount of water heated in this way approximately equals the need for warm water on dairy farms. Therefore, it would not be efficient to transport this warm water elsewhere and to use it for different purposes. In winter, however, the supply of warm service water may be insufficient because the amount of milk obtained is smaller and heat losses before processing are greater than in summer, then it will be necessary to achieve the required water temperatures by electric heating or by use of a central heating system.

Long-Term Measures for Milk Production in the SSR -- Outlook for the Year 2000

It is expected that with the steadily increasing number of dairy cattle, the yearly milk production in 2000 will be about 2 billion liters. We can also expect that that milk will have to be cooled and that waste heat will be used for heating service water. Then it will be possible to heat about 1 billion liters of service water to a temperature of 50°C, which will save 46.51 GWh [Gigawatt hours] of electrical energy or 600 TJ [tera joules] if converted into primary fuel.

Research Tasks

Researchers are presented with the task of developing required equipment of minimum size and maximum of safety and reliability. Manufacturers should be primarily responsible for the development and production of this equipment and its parts. As in the research and development work for heat pumps and industrial cooling systems, all work in this area must be directed toward a maximum economy in energy consumption, a maximum reduction of equipment size and a maximum in safety and reliability. The equipment must be completely automated, including the offtake of warm service water, qualitatively treated and heated to required minimum temperature (about 45°C at the point of leaving the heater), at which a minimum heat loss in the warm water piping system can be obtained.

Biological Gas

The problems of production of biogas are now new. In the area of drycleaning technology, anaerobic fermentation has been used for degradation of organic matter for 20 to 30 years. Although some experiments with the production of biogas on dairy farms have been more or less amateurish and failed both economically and operationally, the large fattening facility at Trebin was the first farm in the CSSR which applied anaerobic fermentation in processing liquid excrements and city sewage in a manure terminal. This manure terminal has worked successfully since the sixties. At present anaerobic fermentation of straw manure is successfully used for generation of biogas in the JZD [Unified Agricultural Enterprise] Uncovice. Construction of testing facilities for the generation of biogas is being prepared at the dairy farm in Mliecany, Dunajska Streda District, and the poultry farm of the East-Slovakia Poultry Plant in Salgovnik.

In the CSSR the problems of research and development of generation of biogas are studied at several organizations:

--The Institute of Physiology of Domestic Animals of the Slovak Academy of Science, Kosice, Ivanka pri Dunaji facility;

--Hydroprojekt Prague;

--The Institute of Microbiology of the Czechoslovak Academy of Sciences in Prague.

The problems of biogas production are more advanced abroad than in the CSSR, even though at the time the manure terminal on Trebin was completed, our specialists ranked among the pioneers in this area. The very interesting problems of biogas production from sugar manufacture waste waters has not been developed either. However, at present these problems are being studied at the VSCHT [College of Chemical Technology in Prague], Department of Water Technology and Environment, and at the Institute of Water Systems, cooperating with the Sugar Industry Research and Development Center in Prague.

Considering present knowledge and consistent construction of facilities at animal production farms it would actually be possible to produce a considerable amount of biogas (see Table 5).

Table 4. Amount of Water Heated from 10°C to 50°C During 1981/85 Period

Year	1981	1982	1983	1984	1985
Millions Liters of	776.5	785.5	813.5	813.5	828.5
Water 50°C GWh	36.12	36.53	37.19	37.85	38.53
Conversion to Primary Fuel (Thermal Units)	465.9	471.24	479.75	488.14	497.04

Table 5. Potentials for Biogas Production

Percent of Total Number of Farms	Number of Animals		Biogas Production (Cubic Meter per Day)
50	Cows	1,900,000	228,000
25	Hogs	2,800,000	161,000
10	Poultry	17,000,000	76,500
Total			465,500

Production of Biogas from Food-Processing Industrial Wastes

Food-processing industry wastes are not suitable for anaerobic decomposition, waste water from manufacture of sugar being an exception. Their anaerobic fermentation is essentially similar to fermentation of waste from animal production.

This method for treating sugar manufacture waste water should be regarded primarily as a purification method and only secondarily for production of biogas. Anaerobic fermentation of sugar manufacture waste water removes about 90 percent of its CHSK content, which means a significant step in preventing environmental pollution. The biogas obtained in this way contains only about 50 percent methane. Foreign literature brings evidence that 1 ton of sugar manufacture waste water may yield as much as 2.1 cubic meters of biogas. If waste water in sugar factories is recirculated to a maximum extent, we can obtain roughly 1 cubic meter from 1 ton of processed sugar beet. Given a processing

capacity of 2.0 million tons of beet per season, this represents a production of 4.2 million cubic meters of biogas, i.e., in terms of energy, 70.35 TJ. Abroad, especially in Holland, France and West Germany, this method is widely used.

Proposal for Utilizing Waste Materials From Animal Production Farms for the Production of Biogas

The process of metanogenous fermentation, or anaerobic decomposition of organic matter, has two aspects. First, it must be viewed as a method of converting agricultural wastes into a hygienically acceptable substrate, which retains its fertilizing properties and can be used on soil. We know from experiences abroad that the fertilizing properties of this substrate are approximately 15 percent higher than those of other fertilizers.

Biogas (sediment gas) is a secondary product obtained through anaerobic decomposition. It is a mixture of methane and carbon dioxide with an approximate ratio of 1 to 2, it also contains small amounts of other gases (0.5 to 4 percent). On the average, it is possible to obtain approximately 1,000 liters of biogas from 1 kilogram of decomposed organic substances. Table 6 shows how much biogas we can obtain if only 35 to 60 percent of the organic substances decomposes in the tank.

Table 6. Potentials for Obtaining Biogas from Excrements of Individual Kinds of Animals (Cubic Meters)

Animal Kind	Biogas Production (ks/h [Cubic meters per hour per animal])
Dairy Cows	1.5
Young Cows	1.1
Hogs	0.23
Poultry	0.009

The composition of biogas, especially its methane content (55 to 70 percent), depends on the kind of excrement, its pH, value and temperature and composition. The heating value of biogas fluctuates between 22 and 26 specific units, according to the content of methane.

Production of Fuel Alcohol

One of the interesting problems in the area of the fuel-consumption rationalization and energy conservation worth special attention is utilizing biomass and waste products for the manufacture of fuel alcohol. These problems are now being studied in the GRT LIKO Institute. The problem-solving department of the institute handed over several well-developed technological/economic studies to the SSR MPVz. Further steps have not yet been decided.

Proposal of Measures

To further promote anaerobic fermentation in manufacture and to increase the effectiveness of fermentation, it is desirable to increase the content of dry substances, shorten its decomposition time, to directly heat the fermentation material, to make the utilization of biogas more effective, to use recovered heat for generating electric energy, to use mobile equipment in gas purification, to provide standard complete technological equipment for practical anaerobic fermentation, and to complete a design for complex reactivization of biogenous substances and apply it, so that it becomes a part of the wasteless technology circuit and is not simply a terminal.

Small Hydropower Stations

The uses of new and renewable energy sources is required by the fuel and energy consumption program of the 5-year plan and its outlook to 1990. Apart from thermonuclear fusion, which is part of the nuclear power engineering development program in the CSSR, among primary new or unconventional sources of energy are solar and geothermal energy, and application of biogas and thermal pump technologies. In a wider sense, however, we can include the hydropotential of small hydropower stations.

Present Situation

Changed economic conditions lead us to consider not only the construction of new large hydroelectric power stations but also smaller electric power stations. If we wish to continue using small power stations we must also continue our research, development and manufacture of turbines, generators and other equipment without which modern small hydropower stations cannot operate. If we consider that in the future these small sources should save us about 2.5 million tons of fuel each year, the question of rapid development of small hydropower stations is worth special attention. As early as 1930, 10,787 small hydropower stations with a total installed capacity of 190 MW operated in Czechoslovakia. In Slovakia there were 273 power stations with installed capacity of 5 MW.

Instead of receiving increased interest, this cheap source of energy was gradually forgotten despite extensive channelization of rivers, which is favorable for small power stations. As early as 1950, the number if small hydropower stations in the CSSR decreased to 4,392, though the installed capacity per power station had increased from 0.018 MW to 0.077 MW. The number in Slovakia had also decreased by almost 160. At present, only 256 small hydropower stations are operated in the entire country, with only 6 being operated in Slovakia.

In the CSR, the last small hydropower station was built at Pardubice on the Elbe River; in Slovakia, at Besenova on the Vah River.

Arguments that small hydropower stations are not profitable are no longer valid. There were several reasons why electric power generated in these small stations was expensive.

In 1954, small power stations' inventory was audited and it was found that most of them used equipment which had fully depreciated in value. Therefore, fictive values were repeatedly ascribed to the operationable equipment. Thus, the production costs for 1 kWh appeared to increase. A 6 percent annual payment was assessed soon afterward on the assigned depreciated value of the basic equipment and lease payment on the water works. It may sound paradoxical, but as a result of these measures electricity generated by water power could not economically compete with that generated in thermal power stations. Although neither river gradients nor flow rates changed, as a result of closing small power stations due to the economic "rules of the game," the national economy lost more than 150 MW of generating capacity.

The Outlook for 1985 to 1990

At present, only 38.35 percent of the enrgy potential of our rivers is used. The significance of small hydropower stations does not rest in large installed capacities but in the large number of operational hours per year, in the operational reliability and low cost of 1 kWh in comparison with the cost of 1 kWh generated in other ways. The high reliability and considerable efficiency of small hydropower stations are evident, for example, in the Cinkova Pila power station in Sumava, which was built in 1912 and has a capacity of 100 kW. During 1977 it operated for 4,450 hours, i.e., 50.8 percent of the year. The experience with the operation of small hydropower stations should be applied in constructions of new stations, with their effectiveness being increased by use of standard designs and standardization in the manufacture of turbines and generators. A convenient system of automated remote control would further improve their operation.

Realization of Objectives

In accordance with the CSSR Government Decree of 20 November 1979, construction of small hydropower stations must be planned within the potentials of our economy. Therefore, it is primarily important to maintain, repair, and rebuild the facilities presently available.

This is not easy in the case of small hydropower stations, since many of them have been operating for 30-40 years without repair. Facilities which have been closed but whose technical conditions (especially of head races) permits operation after minor repair or maintenance have been performed should again be put into operation. Agricultural enterprises especially should direct their efforts to this area because they can find here at least a partial solution to their problems of electric consumption.

In December 1980, the SSR Ministry of Development and Technology developed a "Proposal of a Complex Program for the Reconstruction, Renovation and Construction of Small Hydropower Stations to 1990," based on CSSR Government Decree No 304 of 20 November 1979 and the following SSR Government Decree No 17/80 of 9 January 1980. Seven of 64 registered local power stations controlled by the SSR MPVz have been included in this Complex Program (see Table 7).

Table 7. Power Stations Included in SSR MPVz Complex Program

Power Station	Installed Capacity (kW)	Average Annual Production (MWh)	Investments (Millions Kcs)
Blatna-Greater Bratislava	38	333	3.8/1.5
Sucha nad Parnou-Trnava	44	306	4.4/1.7
Nemecky-Topolcany	38	285	3.8/1.5
Kozi Vrbobok-Zvolen	26	204	2.6/1.0
Sebechleby-Zvolen	18	180	1.8/0.7
Sigord-Presov	20	201	2.0/0.8
V. Rybnica-Michalovce	100	790	10.1/3.9

These investments will result in using small hydropower stations with an installed capacity of 284 kW. These small power stations will generate annually 2,299 MWh, which will save for the food industry sector 2,030 tons of lignite or 700 tons of light heating oil or 890,000 cubic meters of natural gas.

Measures Proposed

We propose to explore the possibilities of using rivers controlled by our ministery and to develop a proposal for their use for power generation. Secondly, to issue a directive for food industry sector development organizations instructing them to consider using the energy resources of rivers while designing channellization.

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COMPUTERIZATION NOW WELL ADVANCED IN HUNGARY

Budapest FIGYELO in Hungarian 19 May 83 pp 1, 7

[Article by I. W.: "No Longer Learning"]

[Text] "Computer technology and microelectronics must receive special attention in long-range medium-range planning work," said Lajos Faluvegi, deputy premier and chairman of the National Planning Office, at a computer technology conference on "Applications of Computer Technology and Future Tasks in Hungary," which was held by the Central Statistics Office 17-18 May. Excerpts from his talk are published below.

Computerization began late in our homeland and was relatively powerless and slow until the end of the 1960s. For this reason the guiding organs worked out a technical-economic concept for the development of computer technology in 1969. On the basis of this the government initiated a central development program in 1971 to reduce our backwardness in computer technology manufacture, installation and use and to coordinate development. The goal of the program was to lay the foundations for and spread computer technology culture and to organize the manufacture of modern computer technology. Evaluated below are the experiences of the more than 1 decade since it can be established that this program had a key role in starting us on the path of domestic introduction and spread of computer technology and in introducing third-generation electronic technologies in domestic industry.

Swift Development

The front line of domestic computer technology has gone beyond the phase of learning and experimentation and has emerged from the professional isolation of scientific workshops and pioneering user organizations. We have created such important elements of the domestic infrastructure of computer technology as a research and development target program and its institutions, manufacturing capacity corresponding to the international division of labor, institutional and study course frameworks for training expoerts, especially programmers, and an institutional system for organizational and developmental activities. The technical and intellectual foundations for applying computer technology have developed in many areas of economic life--in production and trade alike--and realistic conditions for use have been defined.

When the program started, we adopted a family of third-generation computers--which were modern at the time. Subsequently, however, we have not been able to keep pace with the trends of international development. The great sums expended are not being used in a sufficiently organized way, and many types of machines and systems came into being in numbers a good bit greater than justified. About 3,000 users--with various levels of preparation and acceptance--make use of these. In the future we must build up a system which is better coordinated technically and technologically. This could contribute to complementary advantages in applications.

At the end of last year the gross value of traditional computer technology devices used in the Hungarian economy reached 21 billion forints, about 40 percent of which were products of domestic industry. In addition to partially satisfying domestic needs, our computer technology industry has undertaken a significant role in socialist export, and its convertible export is increasing also. Annual production already exceeds 6 billion forints and will reach 8-9 billion forints by 1985.

This swiftly developing area is also characterized by the fact that in our homeland the majority of the machines are kept in operation by their users to the upper limit of their physical life expectancy. In the most developed industrial countries the replacement cycle is 4-5 years. Naturally our material assets do not permit such frequent replacement. But the other extreme is that already 10 percent of the equipment now operating is older than 10 years and almost 20 percent is older than 7 years. This means that almost one-third of our computer inventory originated before the "revolution" of the microcomputers, which can be dated from 1975.

It is a serious problem in investment in computer technology devices that the technical level of computer technology and microelectronices lags behind that of a number of countries with similar economic conditions (for example, the GDR or Austria), that the variety of domestic manufacture and socialist import is most modest and that the price level of our machines is substantially higher than that of the world market.

The possibilities for developing remote data processing and computer network systems have improved since the Post Office put in operation a control center for a line-connected data transmission network. But it must be noted that remote processing is still undeveloped. A more significant expansion runs into the deficient capacity of the traditional telephone network and sometimes into other technical problems.

A good part of our use of electronics and computer technology is based on the interest, preparation and economic possibilities of individual enterprises and institutions, but in light of the foregoing there is a need for state guidance in this area.

Three Phases

There are three phases in the development or application of computer technology and informatics. The first is when computer technology develops as a primary

activity, that is, when computer technology "is present" in computer technology. The second is when computer technology conquers the most important areas of the national economy, gets into the "arteries" of the economy. And the third is when computer technology and informatics spread generally in the economy and in society, "permeates the capillaries of the economy and society."

At present the development of domestic computer technology stands at the border of the first and second phase. To meet our economic and social goals, we must enter the third developmental phase in the shortest possible time! This can be imagined only if we proceed with the tasks of the second and third phase simultaneously. So we have the task of expanding the use of computer technology while bringing it to a new qualitative level, shortening that time in which computer technology "permeates" the circulatory system of the economy and of society. It is a condition for this that there be a mutual effect and a division of activities among users and the economic guidance which creates the conditions which will aid this most effectively.

We have the task of preparing and implementing a broad applications program, giving priority in industrial policy to the develompent of efficient production which aids electronicization and posing for scientific research new requirements in harmony with the growing production and application tasks.

The government recently passed--on the basis of a proposal of the State Planning Committee--a resolution concerning a transformation of the computer technology central development program to accelerate development and spread applications. According to this, the emphasis in state economic organizing activity in the future must be placed on coordination of conditions for computer technology solutions and applications. The requirement is that the program system should include the production and use of hardware and software tools, the research and development necessary for this, general and professional training, international cooperation and contact with border areas, primarily with automation, broad use of microprocessors and
In the course of developing the program--in the year ahead of us--we intend to study whether it is necessary to develop a comprehensive social-economic program for the 7th 5-year plan which would incorporate ideas and tasks pertaining to the manufacture of electronic devices, user applications and developments in informatics and telecommunictaions, and if so what conditions might be needed.

Requirements

The most important finding, which is also a requirement in production, trade, international economic cooperation and research is that the products incorporating electronics, microelectronics or any other manifestation of informatics should be internationally competitive. The development, manufacture, trade and use of products containing electronics and enterprise behavior in connection with them will differ substantially from present practice. The life cycle of such products is short, forecasting market needs in connection with them is uncertain and the manufacture of them is more flexible. For this reason--where possible--we must strive to manufacture on an an ad-hoc basis products embodying greater intellectual work, taking into consideration our material and intellectual assets. Because of our small

domestic market and in the interest of advantages which can be attained by virtue of international economic cooperation we must prepare at the same time for manufacture in economical series in certain manufacturing cultures. A rational combination of these two chief trends will show us the path to be followed in both industrial development and applications.

Improving the production and user culture is primarily a question of comprehensive industrial development, especially a question of renewing the microelectronics industry and, connected with this, of renewing the entire management process.

The increased production and applications tasks pose new requirements for domestic research and development work and for coordination of this work. Long and medium-range programs for these tasks are now being prepared.

While we are developing programs for computer technology applications, production development and target-oriented research and development, we must also take into consideration the possibilities of and conditions for the development outlined. In the course of this the first thing to note is that for well-known reasons it will be difficult, in the years ahead, to bring the computer technology, electronics and communications needs into harmony with the resources for satisfying them--whatever we might wish. We will have problems in acquisition also, partly because of the narrow socialist import variety and partly because of the embargo policy of the capitalist countries.

The Economic Environment

A further development of national economic and enterprise planning, of the economic environment and of the regulator system is an important condition for carrying out the strategic tasks of electronicization. We must find those conditions which will help spread electronic solutions and the use of computer technology with the indirect tools or regulation. In connection with this, we may meet with views which oppose the use of modern computer technology methods and tools in planning and guidance with the requirements of adapting to the market. In reality they presuppose each other.

In the future we intend to form the economic-legal environment affecting computer technology use in such a direction that the pertinent intentions of the management organizations should also serve the interests of the national economy. To encourage this, it would be useful to modify price control in such a way that there should be greater interest in modernizing products; in wage control we want to improve the earning possibilities of qualified experts at "break-through" points and in the "driving" branches; and we would modify financial conditions so that sufficient resources are available to carry out the most important research, production and applications tasks, so that credit and various concessions should continue to aid the realization of stressed development programs.

The spread of electronicization cannot be the job of a few institutions or enterprises. In the broadest sense this is a social task which requires the many-sided cooperation of science and practice, of production and foreign trade, of developers and users.

There is also an opinion that computer technology can take the place of many-sided deliberation, of responsible decisionmaking, as if we could automate guidance processes. Rather, it merely transfers these to another, higher-level, more organized medium. Into a medium in which there must still be a realization of responsibility, democracy and the driving forces of society; and certainly the possibility of error cannot be excluded here either. In this respect we must reckon with certain limits of even computer technology culture. We cannot expect miracles from computer technology; but it is certain that it does create a brand new field for thought. It discloses new possibilities for improving socialist social and economic relationships, the exploitation of which is indispensable in that developmental phase so that our homeland may enter the ranks of the developed countries.

8984
CSO: 2502/38

COMMENTARY ON DECLINE OF SCIENCE REPORTED

AU201005 Warsaw SLOWO POWSZECHNE in Polish 17 May 83 pp 1, 2

[Commentary by "(J.R.)": "The Crisis of Science"]

[Text] There is a general view that our science is increasingly lagging behind world science. There are many reasons for this, and one of them is said to be the insufficient funds for scientific research, which amounts to 1.8 percent of the national income. Only modest funds have been provided by the national socioeconomic plan for this purpose because of the difficult economic situation. It should be added that scientific research units receive their funds from two basic sources: From the budget and from the central fund for technological progress, which consists of special taxes paid by enterprises. The future of this fund is uncertain.

The procedure of economizing is compelling us to concentrate our forces and resources, but what is important is the concept and lines of this concentration. Scientific communities are at odds in evaluating the research priority and funds granted to research in the food economy, in construction, savings of materials and energy, and rationalization of imports. However, we should realize that it is difficult to decide which research is more important and that it is necessary to prevent a dispersal of funds. Moreover, there is concern for the future of those areas of the economy that have not been granted priority. The problem is that certain lines and themes of research may disappear or may produce poor results because of the shortage of funds. The old dilemma has appeared: Are we to honor short-term or long-term needs?

There is always an element of risk in science, and this concerns more than just basic research. At times, many years of a researcher's work are wasted and at times many years elapse between a discovery and its practical application. Perhaps it is this that is responsible for the tendency to give priority to the research that produces spectacular results and is distinguished for its utilitarian character. For example, the plan for science and technology in 1983 provides for the practical implementation of 110 design and technological solutions and of 10 investment tasks produced by government programs and those dealing with key problems. Let us add that the government's orders involving 200 tasks will help stimulate the extensive scientific research base. However, this concept cannot as yet be regarded as thoroughly finished because, for one thing, the proposed solution must not be restricted to placing orders; it must also involve practical implementation supported by the sides concerned such as the managing center, the scientific research unit, and the recipient, that is, the enterprise.

This concept is interesting, but one may be concerned for its feasibility. It is not without reason that views are being expressed that enterprises show insufficient interest in technological progress because they can prosper without any major technical and technological changes in production.

We must wait for the complete exploitation of our scientific potential. This is true of all levels of science, including higher schools and the Polish Academy of Sciences. One would expect that at a time of crisis and in the face of threats to science measures would be taken to ensure integrated activities. However, little has been done in practice in this regard. There is no dentral body in charge of the development of science and technology because neither the Polish Academy of Sciences nor the Ministry of Science, Higher Schools, and Technology are such a body.

It seems that disputes as to the areas of competence are beginning to emerge. Some people demand that the Ministry of Science, Higher Schools, and Technology should set up a separate government body responsible for stimulating and coordinating scientific research, and some want to entrust the Polish Academy of Sciences with the responsibility for research (or, broadly speaking, for science). The lack of a law on scientific institutes complicates the situation.

Struggles for prestige may cause the disappearance of the basic problem--the state of science--from the field of vision. And yet it is a fact that science is struggling with many difficulties and that the charges made against it, that its potential is dismembered to an excessive extent, that scientific research is being doubled, and that science is isolated, are not attended to with greater and more specific attention by those concerned. It seems that the time has come to resolutely discuss these problems and to make binding decisions in order to be able to answer the question: What should be done to improve the situation? The simple fact is that we must not dawdle.

CSO: 2602/25

SCIENCE POLICY, SITUATION, CRISIS REPORTED

Crisis in Science

Warsaw ZYCIE GOSPODARCZE in Polish No.16, 17 Apr 83 p 9

[Article by Urszula Zatorska: "Science in Crisis"]

[Text] "Polish science has been trailing the world science and has less and less means at its disposal," said representative Waldemar Michna at a session of the Sejm Commission for Science and Technological Progress. This estimate, shared by the entire scientific community, did not make the discussions of the draft national economic plan for 1983-85, namely, the section concerned with science and technology progress, any easier. The scarcity of allocations for research and development in the draft three-year plan, which also provides for concentration of research on four selected areas (food industry, construction, savings of materials and energy, and efficient imports) caused many doubts.

The question was asked, what is going to happen to other disciplines? It was debated whether it might be better to spread the available means thinly to cover all areas of science so as to avoid an irreversible loss of the current research potential, or do the opposite and verify the usefulness of research and keep only that most needed for the economy. Can one save on science by mechanically cutting outlays and funds or limiting access to research, or, rather, develop in crisis those areas which are more likely to bring economic effects? Many such questions were asked, but not all of them were answered by the participants in the conference.

Representatives also noted that enterprises still show little interest in using the results of technological progress, because they can thrive even without working well, without savings, without modern methods. As Professor Jerzy Lutowski put it, there is no "economic transmission" for effective utilization of the available research potential in practice. Factories are reluctant to introduce innovations, fearful of the risk and costs involved. Without interest on the part of industry, the scientific research facilities are meaningless. Innovations and new ideas cannot sit on shelves, but should bring practical effects. It was thus proposed that allocations for research and development partly be used to promote application and reduce the risk taken by enterprises.

The general consensus was that outlays on research and development, amounting to 1.8 percent of gross national income, are too little and insufficient even for the most necessary spending. Research and development centers are financed from two sources: budget means and central fund for technical progress (created from a special tax paid by enterprises). They can also produce marketable goods, and the profits are spent on financing their activity. Representatives spoke in favor of modernizing the statutes regulating the financing of enterprises (introduced last year), specifically article 42 on obligatory allowance for technological progress. It was proposed that the obligatory nature of the allowance be extended to 1984-85, thus to facilitate financing of research and development centers and industrial innovation.

To provide incentives for contributions of research and development facilities to accomplishment of plan tasks, the plan envisages a new mechanism of research and development incentives. The so-called government orders will cover some 200 different tasks to be resolved. At the current stage, however, as emphasized by the speakers, the concept of government orders has not yet been worked out in sufficient detail. Placing an order is insufficient. The system of orders must also include provisions for applications--that is, in practice be based on trilateral contracts: ordering center-research and development unit-industrial enterprise. An overall arrangement will thus be required.

Discussions focused on the proposal by the Ministry of Science, Higher Education and Technology to greatly reduce the college enrollment in 1983-85. This will primarily concern evening classes, with a 54 percent reduction of enrollment for working students in 1985 compared with 1982, as well as day students at higher technical schools, where the enrollment is to be reduced by 34 percent, in economic academies by 24 percent and in agricultural academies by 14 percent.

Minister Benon Miskiewicz said that the main reason for reducing enrollment is not the crisis but a lack of demand for college graduates and the need for putting in order the entire system of education. The ministry postulates that overproduction of college graduates does more damage than partial shortages in any particular period. Representatives, however, pointed out that the reductions are too large and that cutting access to college for young people is too drastic. While not denying the need for more order in matters of academic enrollment, education quality and teaching staff, they proposed, however, to retain the enrollment in 1984-85 at the level of 1983.

Science Policy, Situation

Warsaw NAUKA POLSKA in Polish No 5 Mar 82 pp 3-62

[Report of an expert committee of the Polish Academy of Science (PAN): "Report on the State of Polish Science"*]

[Text] The "Report on the State of Polish Science" is a result of work by the Science Studies Committee of the Polish Academy of Science [PAN]. Work in this area was started in mid-1981. Initially, the time of completion was scheduled for the third quarter of 1982, but was reduced; first by the Presidium of the Academy on 24 November 1981, and subsequently at the session of the Scientific Secretariat of the academy on 10 February 1984. The report, as presented to the presidium of the Academy of Science on 22 March 1982, was prepared jointly. The project was supervised by Ignacy Malecki, chairman of the Science Studies Committee of the Polish Academy of Science. Members of the committee were: A. Buttler, E. Halon, S. Kwiatkowski, S. Kowalewska, E. Olszewski, M. Pogodzinski, J. Ruszkiewicz, K. Szaniawski, B. Walentynowicz and E. Zakrzewski. The report is based on materials prepared by secretaries of the respective departments of the PAN.

The report has the following tasks:

(1) depict the current situation of science in the country, evaluate the objective conditions and actual potential of science and delineate its current and future roles;

(2) set forth the principles of the scientific community in regard to advancement and directions of scientific research in the 1980's; and

(3) propose to the government the premises of a science policy that would ensure effective scientific activity in this period, especially as the nation emerges from the crisis.

The report is a synthesis. It presents--with inevitable briefness--the aspsects which are crucial, according to the authors, for the current situation of science in Poland and for its future development. Analytical

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*The "Report on the State of Polish Science," containing ample conceptual and factual material, has been prepared within 3 months'time. This was made possible in particular because of the use of materials collected in earlier expert reports by the Science Studies Committee; fragments of these reports have been printed in NAUKA POLSKA. These reports included: "Trends in Improvement of Science Policy in Poland" (1976), "Improved Application of the Results of Scientific Research in Industry" (1979), "An alysis of Directions, Methods and Areas of Education and Continuing Education of Scientific Personnel in Poland" (1979), "Outlays on Scientific Research and Development--Evaluation of Level and Structure" (1980) and "Necessary Outlays on Scientific Research and Development" (1981).

We believe that this report is, as it should be, a vital updated document created on the basis of studies and statements of scientific committees of the Polish Academy of Science [PAN], scholars and activists. We will appreciate suggestions and comments by readers of NAUKA POLSKA concerning the concepts contained in this report that will be of help for subsequent work by authors of the report (Editors).

work that will discuss in detail the socioeconomic changes in the country will be the subject of a second stage of studies planned for the future.

Part I: Directions in Development of Science

Science has a dual goal: first it seeks to learn the objective truth about the real world, in this way meeting the human need for knowledge; and second, it defines the rules for optimum activities aimed at meeting the practical needs of society. While science is universal and concerns all mankind, it is closely linked with the historical realities of each nation, which determines its development and socioeconomic and cultural use.

The tasks that science undertakes for immediate implementation define the scope of its social effects--this is the area of the impact of scientific knowledge. Science, however, also has indirect effects. The very existence of science--both through its internal intrinsic dynamics and its institutional and organized activity--exerts major influence on the various spheres of a nation's life.

The complex nature of science calls for considering its actual accomplishments and future evolution in close connection with the situation in the country when discussing the projected and required changes of the situation. At the same time, one should bear in mind the specific universal nature of science and the need for maintaining the individual exploratory results at the level of the world science.

It should also be considered that, depending on the nature of research, the methods of study and criteria of evaluation of its results may differ; the premises of a science policy would also be different.

The term "science" has a too broad meaning in its everyday usage. This concerns both industrial management, statistics, public opinion, finances and administrative decisions of the government. The term is applied to spheres of practical activity, especially concerned with advance and introduction of technological achievements. This frequently leads to unjustified or outright false decisions.

The term "science" is frequently abused in other forms: the authority of science is used to endorse purposes that have nothing to do either with science or with its interests. This broad interpretation of "science" should be opposed. The term needs social protection in the same way as law protects scientific titles and degrees.

At the beginning of a "Report on the State of Science" it should be stressed that the term "science" can properly be used only in its narrow sense, namely, when it refers to basic research or applied research.

Basic research seeks above all to accumulate scientific knowledge, as ordered, socially accessible collections of properly substantiated infor-

mation on the objectively existing real, natural and social phenomena. This research provides answers to such questions as: What is this or that fragment of the world like? The basic criterion of research is its truth, i.e., the degree to which information resulting from it reflects reality.

Applied (practical) research seeks to meet practical needs, answering such questions as: What has to be done to meet these needs in an optimal way? The practical knowledge that consists of answers to such questions takes mainly the form of rules for certain actions which subsequently form the base for exploratory or developmental work--creating designs, processes and organizational forms. The basic criterion to be considered in applied research is its utility.

Applied research also includes--which is often disregarded by us--determinative (evaluative) studies. Various studies provide answers to questions such as: What conditions should be provided when performing a certain activity planned in advance to ensure the human needs; for instance, what will be the environmental effects of an industrial construction project?

There is no sharp boundary between basic and applied research. Actually, each research accomplishment has a cognitive factor and an element of novelty. At the same time, it can be used to meet a certain area of human needs. An expression of these needs, after all, is also the typically human cognitive curiosity.

Participation of scientific research in activities aimed at meeting various human needs varies depending on the type of these needs. In social areas, this participation is different from the economic sphere. A science policy is linked with priorities of social policy and economic policy, although it is not determined by either in a mechanical way. Priorities of a science policy, although being a function of social and economic needs, have an independent essence which derives primarily from needs of cognition inherent to science itself.

1. The Role of Science in a Nation's Life

The practical role and significance of science in the life of society is determined by two systems of relationships. On the one hand, they are determined by the objective conditions of scientific activity, and particularly provision of materials or substantive requirements necessary for its function. On the other hand, and no less important, are the actual accomplishments and social relevance of scientific knowledge, as well as efficiency of other forms of influence through which the permanent presence of science in society is manifested. It should be noted that the role of science was not truly estimated or properly understood either by the authorities or by public opinion. This has frequently led to misunderstandings in evaluating the usefulness and possibilities of scientific research. Sometimes the impression that the authorities

acted as a benevolent sponsor of science without any conviction that this is a sphere of activity vital to the nation.

The role of scientific research differs in basic research and applied research, but these differences are quantitative rather than qualitative.

The most obvious effect of science is direct transfer of results of research, mainly applied research, into practice, such as in development of prototypes of equipment, calculation methods, new plant varieties,, medical treatments or social investigation forms. The situation in Poland in this area can be characterized in general as follows: Numerous highly skilled scientific and technical personnel working for direct needs of applications mainly at industrial enterprises, ministerial institutes and research and development centers, as well as partly in academic institutions, possess powerful potential and have scored major results, sometimes of a leading worldwide importance. However, the number of results implemented in practice is incommensurably small compared to the achievements. The situation has been gradually deteriorating since 1974, when many of the research facilities were transferred from industrial enterprises, where they were governed by the so-called self-financing principle, to the state budget. Improving the mechanisms of application of research results should become a major condition for raising the effective impact of science.

No less important than direct results are indirect effects of science on the practical sphere, which are frequently overlooked by decisionmakers, for one thing because they cannot be evaluated in terms of immediate economic profit. Participants in these indirect effects are centers and units of all three sections of science (higher schools, institutes of the PAN and ministerial institutes), as this concerns both basic and applied research. Most often this concerns dissemination of scientific knowledge --especially knowledge that has a practical value--among broad circles of practitioners in the form of manuals, monographs, instructions or standards, as well as through continuing education of industrial personnel in practical training and refresher courses.

These forms are fairly well organized in Poland. Before the crisis in publishing, our medical, agricultural and technical books had a generally high level and were read in industrialized countries, while Polish technical norms in scope of coverage and elaboration level were not inferior to their foreign counterparts. Introduction into practice, however, is the weak point even here. For instance, updated projects and designs that ensure savings in material often cannot be used in practice because of the uneven quality of materials due to the fact that the standards essential for this production are not observed; medical treatments cannot be practiced because of shortages of drugs; methods developed for production of metals and other materials--which are of great importance in reducing imports--have not found recognition in industry because of the obligatory principles of calculation and reluctance to take any risks.

The social function of science cannot be reduced to use of cognitive results (theoretical or practical), or to dissemination of efficient principles. Scientists--as well as other creators of culture--take part in social life with a special status, enjoying both interest and trust of society. This trust stems from the recognition of intellectual integrity of scientists and even more from the recognition of their intellectual competence and efficiency in their respective areas. This credit can, of course, be withheld. During the period of ubiquitous crisis of authority, this would mean major social damage. Respect for intellectual independence of the scientific community under such circumstances is an important requirement.

The effects of science in culture and education are, of course, connected. Scientific knowledge is the subject matter of educational instruction, and, what is more important, forms the essence of education indirectly as a cultural factor. The social consciousness and its identity are largely determined by the available historical, sociological and philosophical knowledge--certainly provided that this knowledge attains wider social spheres. In addition--and this is sometimes forgotten--science provides patterns of thinking. It is desirable for society that scientific methods of thinking be disseminated, as they are based on logic and experience, which place the truth and integrity at the top of the hierarchy of values. This refers also to the culturally creative function of science.

The humanities--including aesthetics, philosophy and literary history--exercise a substantial influence on those who create art and those who consume it: arouse interest, form attitudes, breed values. In this manner they build up the spiritual culture of society. A regression of linguistics in Poland, the decline of importance of philosophy and breaks in continuity with traditions of humanitarian thought in some social sciences, especially sociology and psychology, in this context should be viewed as disconcerting phenomena.

More concern should be dedicated to areas of scientific expression. Loss of readability in many scientific publications which, among other things, is a result of advancing specialization of interests of the scientific community, causes apprehension. The language of science is subject to specialization, but this feature should not be in conflict with the use in its vocabulary of concepts and phrases of everyday language.

There is a clear tendency towards formalization of language in individual disciplines. This process is inevitable for the progress of science; however, it makes communication between science and its social envrionment difficult. These developments concern the language of science as a whole--but they are particularly felt in publications in the areas of the humanities and social sciences, because works in this area affect wider circles of readers, frequently lay audiences. Scientific results are often indecipherable to these people, discouraging

the reader with their tedious style and hermetic choice of subject matter. Efforts should be made to stem this disturbing evolution which reduces the potential impact of science and diminishes its cultural function.

Another phenomenon should also be counteracted. Humanitarian sciences cannot be treated pragmatically, which unfortunately took place especially between 1968 and 1976. Results of this approach in social consciousness are that humanitarian studies should be warranted a considerable independence and safeguards against intervention of incompetent internal factors into essences they produce.

Some scientific disciplines such as universal history or space research enjoy broad public interest and enliven the complete intellectual life. An important contribution here is made by scientific societies. In Poland, they have existed for a century and a half. In the past two decades, their activities--both scientific and educational--have grown greatly. Achievements of scientific societies in dissemination of knowledge cannot be overestimated. They attract amateurs to science and prmote interest in research in various professional communities, such as teachers, doctors, engineers working in industry, etc. This creates conditions for immediate cooperation of people professionally involved in science and those interested in scientific research, its results and social effects. As independent organizations, these societies have the potential for further favorable development, given minimum assistance by the state.

The participation of scientific communities in stimulating the intellectual life of the nation is connected with the willingness to conduct open discussions. Controversies have always attracted lay public as well as intellectual participation; in other countries, examples are known when workers' communities are interested in such issues. For the scientific community, controversies are a precondition for creativity. In Poland, however, this form of interaction is quite small. This is a result of scientists striving towards narrower specialization and the tendency for self-censorship, as well as to the fear that scientific discussion will become a polemic about the value of individuals conducting public discussions. The long-observed decline of scientific criticism and conformism of presented views are disconcerting. This concerns not only often-cited obsequiousness of certain groups of science vis-a-vis the authorities in the 1970's. Engagement in discussions is also quite weak within the scientific community. This climate cannot be changed by administrative enforcement, but it seems that increased self-management of the scientific community is bound to raise among scientists a sense of responsibility for the quality of work, both their own and of their colleagues.

It is a truism that scientific research is an inherent component of activities of higher educational institutions. That this is true is confirmed by centuries-old practices throughout the world. Technically, this has always been their obligation in Poland, although deviations from this attitude have also occurred. In the late 1950's there was a drive to concentrate research at the PAN, confining universities to edu-

cation, while in the early 1970's there was a swing to the other extreme when research was given preference at the universities at the expense of education.

This does not change the fact that higher schools should remain in Poland the area concentrating most basic research. This is in fact the strongest community for development of scientific talent.

Science has an essential influence, not only on the education process, but it also has an educational function in breeding the new generation of young scientists. We will return to problems of scientific labor reserves in the report, but here we want to note that development of new cadres and having students should be treated as the highest privilege for a professor. The reality is often different. Turning out new bearers of the doctoral degree is a way to promote one's own academic career, and the authority to award doctoral degrees and scientific habilitation is often given too liberally, and rarely withheld, even in the face of obvious abuse in some centers. The autonomy of centers in such cases breeds failure, which makes it necessary, among other things, to continue and improve activities of the Central Qualification Board.

Recently, attention has been drawn, often with criticism, to the role played by scientists in management of various levels and decisionmaking in nonscientific spheres. This issue has two aspects: scientists as consultants and as participants in the government apparatus.

Expert reports or reports prepared by scientific task forces on particular technical, social or economic subjects have been produced many times during the past 30 years, such as reports of the PAN from the 1950's on development of a national power grid system and water management. In the mid-1970's, the activity was institutionalized after the PAN and the Planning Commission signed a contract establishing 12 expert task forces. The value of the resulting reports produced with major labor input was different. Some, such as the report on legally incompetent individuals or on social pathology, were real discoveries--for the first time they presented in a synthesized comprehensive manner certain basic social issues. Others sounded alarms, such as the expert report on the Polish power industry. There were also fragmentary and superficial reports. Most, however, met with the same fate--they were disregarded in government decisions. Especially dramatic was the failure to consider warnings from various scientific communities conerning the devastation of the nation's environment and the Baltic waters. Great public damage has been inflicted by neglecting the conclusions flowing from the report on national education broadly advanced as a scientific premise for educational reform in Poland. Both writers and recipients of expert reports should draw appropriate conclusions from these failures. On the one hand, the reports should contain not only warnings but suggestions of remedies; on the other, those to whom the reports are addressed should be obliged to these suggestions, and in the case of positive recommendations, to take steps to implement them. The principle of scientific advisors in govern-

ment practiced worldwide should certainly be improved and developed in Poland as well.

Another aspect of direct participation of scientists in government is marginal in relation to the overall scientific problems, but requires special comment in light of our conditions. A scientist--whether with or without academic title--placed in a management position above all draws from his personal experience, has his own public function and personally is responsible for particpation in the decisions that are made. It is wrong, therefore, to identify him with the scientific community from which comes, and his decisions cannot be interpreted as scientific decisions or judgments. In view of this, the number of professors in government agencies would certainly not indicate a growth of political, public or economic role of scientists in our country.

This issue is closely related to the the advisory function of scientists. Despite certain depreciation of their role, scientists still enjoy a high public prestige, and public opinion listens to their voices. The situation here, however, is similar to that in government. A scientist talking about his field of endeavor speaks as its representative. However, as soon as he begins to discuss extrascientific matters, he is an ordinary citizen, although he may seem to be supported by the authority of his profession. Statements by individual scientists, therefore, cannot be taken for a basis for evaluating the views of the scientific community. This makes it ever more important to provide scientists with access to mass media to popularize research and breakthroughs and to make the public familiar with the problems to be resolved with reference to the opinions of various interest groups. It is a sociological fact that scientists' opinions enjoy above-average public trust. This can be easily interpreted: scientists are bound professionally to respect truth. In an environment of crisis of confidence, this fact acquires enormous importance.

Science has also a major role to play in creating Poland's authority in the international arena. Polish scientists individually participate in international research programs and are valued in scientific communities of worldwide importance as units greatly contributing to creative work. This activity, however, is truly reflected in scientific work inside the country, which is often conducted at the margins of the world science. Young Polish scientists traveling abroad mostly enjoy the reputation of capable and diligent people, which sheds favorable light on our scientific community as a whole. It should be borne in mind that scientists are a social group that has the widest international contacts. In addition to the above-mentioned opinion-creating role in the nation, this adds to their capacity in forming public opinion to the advantage not only of Polish science but of the entire nation. Strict limitations of scientific trips abroad, publication of journals in foreign languages and purchase of foreign books and journals badly affect these contacts, and it should be known that minimal savings of hard currency may have far-reaching negative consequences.

2. Strategy for Development of Scientific Research

This survey of political, social and economic roles of science and scientists is bascially concerned with the service functions of science which are derivative and not the basic essence of scientific activity. For the world scientific community, the real contribution of Polish science consists of the innovations introduced by our scientists into the treasury of human knowledge. We do not have space here to give a historical evaluation of the contribution which has been analyzed in detail by teams of science historians working in Poland. An objective, although optimistic, overview of the accomplishments of Polish science in the last decade can be found in the book "Science and the Nation's Development" (Ossolineum, 1980).

In this report, we will be confined to a general outline of the factors ensuring the current evolution of science and its future and suggest research priorities.

An outline of the current situation cannot be reduced to an overall assessment, since the level of research is different in different disciplines and areas of science. Yet some general characteristic features of Polish science can be pointed out. On one hand, in People's Poland, a relatively large, well-educated and capable cadre of scientists has been formed and is wokring, and on the other hand, there is a continuing weakness of the material base and shortages of organization that had a negative effect on the evolution of research and its results. Additional factors were the above-mentioned difficulties in application of research results and attempts at imposing control from above in some social disciplines, not only concerning the form but also the essence of studies. As a result, scientific research had a pronounced extensive nature--many, sometimes too many, people were involved in the efforts which lacked in facilities and thus had poor prospects for obtaining important results in experimental research.

In exact and natural science, this led to a situation where major scientific accomplishments occurred in theoretic research--in many of the centers througout the nation and in a largely broad spectrum of subjects. This gives added credit--despite the above-mentioned difficulties--to major results achieved also in experimental science and by theoretic-experimentation teams. These results were obtained at centers which not only possess creative personnel, but were capable of obtaining the research equipment at an adequate level. Illustrations include studies in mathematics, physics and theoretical chemistry, semiconductor physics, magnetic physics, structural studies, bioorganic chemistry, studies of strong magnetic fields, spectroscopy and ultrasonic technology.

In technical sciences, successes were mostly scored in basic investigations rather than with applications of results of technical inventiveness. This concerns, for example, design of building and machine structures or automation systems.

In social science and the humanities, development was characteristically irregular (for instance, the flourishing archaeology of the Mediterranean) with the rather negative selection in sciences lying at the center of government interest (such as economics and, in an earlier period, sociology).

A major shortage of organization of research was the underestimation of the importance of interdisciplinary studies and the use in practice of narrowly specialized subject approaches. This flowed from the scientists' tendency to lock themselves within one discipline or even one branch of knowledge and to limit their activity to one research unit, as well as to the government agencies' tendency to perceive themselves as units independent of the decisionmaking centers, as if they were private concerns in a capitalist nation. The results of these tendencies had consequences both for the economy and for the principles of research. The effects of this attitude were felt the strongest in territorial and community economy, material and water management, and in environmental protection.

On the scale of the entire scope of science, comparing the facilities that are available to Polish science and the results it has achieved, one can say, however, judging from, for instance, the frequency of citation of Polish results in world literature, that we are up to the mean European level.

A positive trait of the entire Polish science is the continuity of its traditions. As demonstrated by the continuity of earlier schools and, most important, directions of research such as in mathematics, history, sociology, physiology, physical chemistry, paleontology, chemistry of natural products and also creation of new strong scientific schools in the Polish People's Republic. Examples include elementary particle physics, solid state physics and physical chemistry, theoretical mechanics, acoustics, coordination, chemistry, neurophysiology and immunology. Surrounding these schools with care is highly desirable because of their international and cultural significance.

The image of Polish science should not, however, be assessed statically, but related to the extremely dynamic evolution of world science. Today the important position of science can be lost easily, but would be extremely difficult to recover. This can be illustrated by the decline in government interest in nuclear physics following its flourishing in the early 1970's. Regrettably, in the past five years, stagnation has been spreading to many other areas of science, particularly those requiring modern research equipment. This leads to a growing gap between Polish science and the world level. This fact is highly important for the entire science policy today. The strategy of surviving crisis frequently proposed for science implies in fact that Polish science is rapidly falling behind world science, although the current conditions demand inevitable losses on the scientific front--these losses should be minimized by most effective strategy for using those means allocated to science.

The strategy for development of scientific research lies above all in setting priorities that would determine the allocation of material means and concentration of personnel. In the section of the report dealing with the systems of science management, it is shown that the mechanisms for concentration of research on selected problems have not been successful.

Scientific research in Poland in most sciences was conducted on an overly broad front, which was broader than would be justified by an efficient division of tasks among research centers, needs of higher education and the national economy, with little regard for the potential provided by cooperation of socialist countries. The "brackets" of priorities were too numerous in science, and for that reason inefficient. The often-practiced tactic of "hitching" to priority problems deprived them of all value. This is incidentally a universal process observed also in other countries, where scientific communities exhibit a natural tendency for uniform distribution of means allocated to science.

The scientific policy is thus faced with the question of whether and to what degree one should counteract this process; should one in a period of crisis spread the modest funds "thin" over the entire field of science, or try to concentrate on select problems. We propose the middle road, so that the entire field of science will be supplied with a thin amount of means, ensuring, however, the preservation of the existing research potential, while the number of priority problems--and accordingly, the number of projects within each problem area--should be reduced to ensure material means that would be sufficient for maintaining the world scientific status and to obtain the desired practical facts.

To preserve primarily the intellectual potential of science, which is the most difficult to recover, it is not enough to maintain the existing number of creative workers in science. They must also be ensured possibilities for continuing application of their knowledge, especially through uninterrupted influx of special literature and--even if on a reduced scale--experimental work and publication of their own results. Nor can we stand for the appearance of a "generation gap." There must be an influx of young scientists that should exceed the natural attrition of personnel by at least 3 percent (foreign analysis suggests a minimum of 5 percent). The need for personnel rotation should also be taken into account.

Depending on the nature of a priority subject, it may require different numerical growth of the personnel, which is in general feasible; the limiting factor, however, is the equipment requirements. In our situation, except for the extraorindary cases, we have to give up projects requiring expensive apparatus. Partial solutions, however, should be avoided, which frequently was done in the past when there was enough means to order part of the equipment, which often made it completely useless. The binding principle should be that a priority project can yield scientific or practical effects only if conditions for its implementation are ensured to the fullest extent.

Reducing the number of priority projects involves revising the current subject plans, not only in numerical terms but also for more exact definition of the scope of problems and sharpening of selection criteria. Scientific committees of the PAN have an important role to play in identifying these problems.

One selection criterion should be the degree of complexity of a problem and support--where large-scale research is required--of a system approach, and the principle of interdisciplinary organization of exploratory work.

Another basic criterion is the importance of the problem for the socioeconomic development of the nation; this, however, concerns only those problems whose solution should be based on results of scientific research. One should not include the problems which in fact are of key importance to the economy, but could be resolved through political, economic or organizational actions, or which are based on introduction of routine technical solutions--this would require only assistance from social sciences.

This limitation of the sphere of action of science is essential for a proper strategy of research. Many reproaches to science and the alleged inefficiencies of its activity come from the assumption that science could independently realize extrascientific goals. Such unfulfilled hopes were in fact the cause of deep crises of confidence in science in capitalist nations in the early 1970s.

From the point of view of the scientific community itself, the decisive criterion is the expected cognitive results--that is, the degree to which undertaken research can contribute to human knowledge. This, however, is dually conditioned: on the one hand, one must reckon with modest capacities of the nation and undertake research likely to be highly efficient, and on the other hand, one must retain the traditions and potentials of Polish science and thus ensure conditions for proper development of stronger centers and scientific schools.

Priorities are first of all considered in terms of means, so that they are not always formally necessary. For certain types of research, limited means are in fact required, but the high social value of their results is essential. In fact, the major error of the system of priority-setting practiced was that only work within the priority's scope was deemed important; this led to creation of artificial "interministerial" problems, for instance, in theoretic physics. We will return to this issue in the discussion of science management.

It should be emphasized that the nature and results of scientific work in different areas are different, so that the final hierarchy of research subjects should result from discussions among groups of scientists or from requirements of that work engaged in practice, but it cannot be imposed through administrative routes. It is also inadmissable that various methods of quantitation of assessments and the criteria used were made into a fetish in practice and became the object of unjustified qualitative fixation.

3. Priority Lines of Research

During the course of discussions conducted when writing this report, a number of proposals were put forward concerning research problems that should be given high priority. These proposals were contained in materials from seven scientific sections of the PAN used in preparing the report. These materials could not be prepared jointly because of the diverse specifics of research work and scientific disciplines, but they constitute general premises for mapping out the guidelines for research on a national scale and serve as valuable indicators for scientists. Based on these materials and discussions with representatives of practical fields (mainly engineers), the first approximate, very general formulation of the priority groups of problems and disciplines has been compiled. Special attention was given to interdisciplinary problems, outstepping the traditional division of sciences.

Problems were represented in terms of their practical results, since basic research can be freely developed in the framework of individual scientific disciplines financed separately.

The list of problems is not complete, and when updating the economic plan, the need made arise for including different, equally important, questions.

The proposals refer basically to the 1980's, with particular emphasis on the needs for the nearest future, up through 1985. Since research programs are mostly compiled for several years, and application of results covers more than five years, continuity of scientific policy concerning priorities should be maintained at least through 1990.

Comprehensive Problems

Comprehensive Problems are concerned with research areas involving key directions of socioeconomic development of the nation and requiring particularly large efforts on the part of science.

1. Modernization and reconstruction of the labor system. This is a starting point for successfull social and economic change in the country. The problem includes, among others, the following issues: wage system, social work incentives, labor laws and employment policies. Sociological, organizational, legal and economic questions are connected here with technical and medical aspects. Solution of this problem will require contributions from many scientific disciplines, especially the social sciences and new, often pioneering research in this area.

2. Organization of government control. Organizing control and raising its effectiveness at all levels of management is a precondition to surmounting the current social and economic difficulties. The model for the economy currently under development that reflects the specifics of Polish conditions requires for its effective introduction a regular collection of data and large-scale theoretic studies in the areas of economics, law, sociology

and other scientific disciplines. Only if it is based on solid research is there a safeguard for avoiding serious errors that were committed in the past in the building and functioning of government systems.

3. Maintaining and raising the efficiency of use of national assets. In the 1970's, there was a growth of national assets which was, however, accompanied by poor utilization and devastation. Management of this property is one way to overcome the economic difficulties. A series of solutions can be expected from the technical sciences, but one should also consider the sociological aspects of people's attitudes about national property. The problem involves, among others, the aspects of reevaluation and utilization of buildings, use of started construction projects and improved operation of machines and equipment.

4. Improvement of preservation and processing of agricultural products. The priority assigned to farming covers the research connected with it as well, which involves not only agricultural science but also social, biological and technical disciplines. This embraces, among other things, the following issues: production of better fertilizers, insecticides and farming machines; reduction of production losses; improved preservation and processing of agricultural products and their more effective use; matters of farming economy and rural sociology. Scientific research in such areas as improved photosynthesis, biological assimilation of nitrogen from the air and genetic engineering open new prospects for agriculture.

5. Raising efficiency of raw material production. Incomplete supply of mineral materials to cover the nation's needs and restrictions on imports call for comprehensive projects of research in improving the management of raw materials. This is aimed at raising the effectiveness of explorations, fuller survey and documentation of deposits, and efficient methods of operation of domestic materials with replacement of imported materials with domestic ones and improved processing technologies. Essential here is also minimizing costs arising from the management of raw materials--from documentation of deposits through mining and processing to distribution.

Water should be included in the category of raw materials, as its reserves in Poland are limited and located in unfavorable positions. Long delays in investments in water system construction have brought a situation which is actually catastrophic. This calls for radical solutions.

6. Territorial management of the country. Territorial management of the nation and its regions is an interdisciplinary problem which is of major importance for improved living conditions of the population and functioning of the national economy. Research in this area conducted by natural scientists, geographers, specialists in urban studies, economists and sociologists, as well as representatives of various fields in engineering, calls for integration into a combined theory of territorial economy. Besides, avoiding excessive centralization in management and introduction of the economic

reform face the theory of territorial economy with new tasks. These are based on creating new planning systems which--while ensuring organizational units the necessary margin for freedom of choice--would at the same time provide principles for organizing and utilizing territories so as to advance the overall social goals.

7. Environmental protection. Long-standing negative phenomena in the environment and its continuing degradation in many regions of the country pose serious threats to health and lives of the people and the nation. The problem, discussed for many years, calls for comprehensive biological, socioeconomic and technical studies. Above all, we must pass on from the standpoint of "protection" to effective elimination of the continuing environmental hazards. This should be based, on the one hand, on preventive measures (mainly in gradual transition to non-waste and minor-waste production and transportation processes), and, on the other hand, to lowering the toxicity of already-existing air, water and earth pollution, waste recovery and vigorous reclamation of degraded territory.

8. Public health protection. The problem embraces several lines of research and the attendant practical activities in prevention, epidemiology, social medicine and labor medicine. This concerns comprehensive studies of factors that can affect the health of the population, as well as social factors, physical culture, patterns of living and dietary habits. Important are investigations involving care for social groups that are at highest health risk (children, workers in hazardous conditions and the elderly).

9. Effective exports and imports. In the past decade, despite extreme centralization, there was no comprehensive approach to these issues. In the current situation, ensuring more effective import and export policies is one of the most important and most difficult challenges. This involves close coordination of technical and organizational studies. The effort will concern particularly pre- and post-license studies and export of Polish technological ideas.

The comprehensive problems affect issues that are most important in the current situation in Poland. In their composition they are not of a scientific nature, but solution of each should be based on results of research and is essential for formulation of research programs. This concerns not only applied but also a series of basic research projects which constitute a point of departure in the quest for desired solutions. This scientific "load" is the criterion for stating the problems.

The Social Sciences and Humanities

The social sciences and humanities have a major culture-creative role to play which follows from the entire course of evolution of these sciences, so that it is difficult to speak of research priorities; broad research is rather required, with certain priority in time and space to issues of current importance for our country and people. Priorities appear in those social sciences which perform an advisory

function for the society and decisionmakers. In this sense, social sciences make a major contribution to comprehensive problems discussed earlier. Of other equally important issues that deserve priority treatment, one should mention the following: (1) social and economic results of economic reform and path of its implementation; (2) the role of the state and law in social assistance; (3) the system of education and its political, social and economic determinants; and (4) methods for overcoming social backwardness and pathology.

The social sciences and humanities require less outlays to perform their functions than experimental science, but they, more than other disciplines, should be provided with facilities to make their results known to the public. This fact emphasizes the possibilities of publishing these results in journals and books.

Biological Sciences

Biological discoveries constitute a base for progress of those applied sciences which embrace living nature. A leading position here belongs to agricultural, forestry and medical sciences, as well as ecology. Intensification and material support should be given primarily to those research directions which lead to new industrial technologies. They are based on molecular and cellular biology, where a rapid growth is noted of biological technology and genetic engineering. The former develops new technologies based on mechanisms and processes observed in living cells which facilitate high productivity, low energy-intensiveness and clean production in terms of environmental protection. The latter allows to create organisms possessing new required features, opening new prospects for agriculture and industry.

A priority area is also environment biology, which is partially encompassed in the above-mentioned comprehensive problem no. 7. Exploring the structure and functioning of mechanisms governing the ecological systems is the basic element of nature's protection and development as the major factor in human environment. Identifying the mechanisms controlling the productivity and efficiency of ecological systems determines the principles for utilization of live resources--farm assets, forests, freshwater reserves, as well as oceans and seas. Lack of understanding of these mechanisms has thus far led to many economic dangers.

A rapid development of priority research areas in biology is also predicated on development of other areas, such as studies in flora and fauna, animal parasites, mechanisms of evolutionary processes and animal neurophysiology. The costs of this research are minimal compared with priority values, and they should be continued on a sufficient scale both for the national needs and for further scientific progress.

Mathematical, Physical and Chemical Sciences

Polish studies in mathematics, physics and chemistry have acquired a high international recognition, and every effort should be made to maintain this prestige. Directions of this research should be concerned with continuing the existence of important scientific schools, maintaing the cognitive and economic significance of expected results and the material capacities (especially in experimental facilities). For these disciplines, international cooperation is important, which is indispensable for maintaining the high level of research. For mathematics an important role in this area is played by the International Banach Mathematical Center, which should be provided the opportunity for further growth.

Physics research in Poland should be concentrated on solid-state, nuclear and elementary particle physics, as well as the effects of electromagnetic radiation on matter. Physics research is mainly of a cognitive nature, but its results find many applications in nuclear technology, electronics and material diagnostics. Activities and further development of the International Laboratory of Strong Magnetic Fields and Low Temperatures are essential in this area.

In chemistry, a series of important research programs are noted, where development will create, in particular, premises for progress in biology, agirculture and many industries. Mentioned here should be studies of organic phosphorus, silicon and sulfur compounds; simple and complex metal and organometallic compounds, and improvement of methods of organic and inorganic synthesis in connection with technology of industrial materials and processes. Of major cognitive importance are structural and physical-chemical studies, as well as chemical catalysis and work on natural compounds from protein groups, sugars, nucleic acids and studies of the role of metals in biological systems. Of an interdisciplinary and practical value are studies in polymers and macromolecules. A growing importance of hard coal as a raw material attaches significance to studies in the coking industry, which in the not-too-distant future will be of major importance for the national economy.

Priority should be given to studies at the juncture of chemistry and physics concerned with structure, theory and dynamics of molecular and condensed systems crucial for progress of the science of matter and likely to be a source of major applications in technology, also leading to insights into the theory of chemical and biological processes.

Technical Sciences

In technical sciences, most research projects are experimental and involve considerable outlays; the national economy indicates the particular areas of the greatest importance. For this reason, research has been concentrated for many years in the technical sciences. Five of eight government programs are directly related to technology. The situation in the national economy calls for revising the current priori-

ties and in view of limitations requires a careful selection. It should also be considered that industry, like no other area of practical activity, has potential for financing research in which it is directly interested.

Besides the priority studies mentioned below, there are projects that are recommended, but usually these are of a fragmentary and short-term nature and cannot replace centralized programs.

Studies that enjoy priority include work on comprehensive problems (materials and machine operation). Other typical technological programs can be subdivided into the following subject groups:

1. Energy production and its effective use. Energy issues are important for the entire economy. Along with the search for new energy sources and improved methods of utilizing existing sources, the fight against energy waste is essential in the current situation. There is an acute need for making the use of energy more efficient by improving industrial processes and building and operating machines and equipment--particularly in communal services. These two questions need support in comprehensive scientific research. In conjunction with the planned building of a nuclear power plant, studies in nuclear technology acquire current significance.

2. Lowering the material intensiveness of production and equipment. Four groups of research programs are connected with this issue, which constitute a basis for improvement of: (a) technical materials (this ia a broad area of technical sciences, so-called material engineering where further specification of priorities is necessary); (b) methods of construction design (leading to optimum shapes and dimensions); (c) production processes (involving better accuracy, speed and reduction of waste); and (d) methods of technical control (improved reliability of technical equipment).

3. Automation and application of electronics. A widening introduction of automation and applications of electronics is a precondition to modernization of the entire production sphere and its competitiveness in the world market. This involves studies towards development of a new generation of computers. Research aimed at improved technology of electron elements and subunits is essential here.

4. Improvement of the methods of transportation and communication. Studies in this area will provide the basis for effective use of the powerful production capacities existing in the nation and will lead to reduction of transportation and communication costs. In this area, cooperation in the framework of the CEMA is particularly valuable--our transportation system should be connected into an integral network with those of other socialist nations.

Agricultural Sciences

In agriculture, the inseparable cohesion of technical, biological and social aspects of research has led to the perception of relevant studies

as the comprehensive problem no. 4. There are also problems that are specific for agricultural and forestry sciences which are primarily concerned with improvement of research methods. Studies of the efforts toward future development should not be negelected also, which concerns above all photosynthesis and biological assimilation of atmospheric nitrogen.

Medical Science

Medical research is inseparably linked to medical practice. Depending on the purposes and nature of research, the following groups of priority problems can be identified:

1. Basic research. This involves the study of processes that can help control the structures and factors at molecular, cellular, tissue, organ and system levels. Particular attention is attached to human genetics, immunology, structure and functioning of the nervous system, the causes of development and mechanisms of neoplastic growth, the regulation of basic system activities (blood circulation, hormones, enzymes, etc.).

2. Clinical studies. This involves pathophysiology, etiology and treatment of diseases having major social impact. Problems concerned with infectious and noninfectious diseases; degenerative and cultural diseases; and occupational diseases; circulatory diseases; malignancies; respiratory, alimentary, nervous and psychic diseases; and new methods of diagnosis and treatment in surgery, as well as development of new drugs and the search for technological progress promoting research in basic and clinical medical science are essential.

Earth Sciences

Among these sciences, the traditionally defined disciplines or branches of knowledge should be identified, which, as it were, lie at the interface of two or more subject areas. All earth sciences are closely related with the national economy and have (especially in the current period) priority value. The problem scopes of interdisciplinary research have been largely discussed earlier in the section on comprehensive problems. As regards the remaining disciplines, one should note above all the importance of geophysics and geology; the development of these two sciences is important for finding new mineral deposits and is closely linked with progress in mining. Oceanography is also important for the national economy as a science concerned with the possible utilization of sea reserves and effective sea economy. Meteorology, with its forecasts, is important for agriculture, communication, tourism and other economic areas; as is geography, which, integrating the results of other earth sciences, is a basic component of the principles of territorial management. One should not underestimate the value of geodesy, the science of measurement of the earth's surface and the base for all construction projects. For the future perspective, earth-space research should also be considered in connection with the "Interkosmos" program; economic uses of these studies have grown.

A special place belongs to studies of polar regions, which have a major political and economic significance. Continuing these studies is indispensable from the point of view of the future interests of Poland.

Part II: Conditions of Development of Science

1. A System for Control of Science

Management of science is conducted by specially assigned institutions at different levels, as well as by participants in research activities themselves. Only if administration and self-management reciprocally complement one another is it possible to obtain reliable results of research, its high effectiveness and simultaneous cohesion between scientific research and the real needs of the country.

Scientific policy is integrally linked with general economic, social and cultural policies of the nation. Particularly close are links between scientific and technological policies. This connection has a dual nature. First, the research and development policies should be subordinated to the policies of economic, social and cultural development. On the other hand, setting goals for this development should be done in consideration of already achieved and planned results of research and development.

In our system of three sections of research (higher schools, PAN centers and ministerial institutes), science policy should be cohesive in embracing also the fear of applications--it should be concerned with determination of the directions of research and also strive to ensure conditions conducive to scientific work and to utilization of scientific advancements.

Scientific policy should have a long-term perspective, stepping beyond the framework of a five-year period, since the time taken to form task force groups and scientific institutions is longer than in other areas of social activity and the practical effects of research take several years to be implemented. This calls for ensuring its continuity.

In the past, science policy on a national scale, as well as within individual ministries, met these requirements only partially. The following negative traits of the existing policy should be pointed out:

(a) lack of coherence and integration between the sections and, at the same time, attempts at their artificial unification--leading to organizational barriers which impeded natural circulation of people and projects, causing large-scale drives for learned degrees and titles, which often was at variance with the basic needs of research centers, especially at ministerial institutes;

(b) inconsistencies and ad hoc decisions in planning and particularly in coordination of research, which led--especially during the past five

years—to unjustified substantial and organizational changes;

(c) scatter of decisionmaking centers, rendering coordination of functions impossible; except for higher education and the PAN, the remaining 1300 research centers are subordinated to 47 ministries or central administrations;

(d) excessively detailed intervention in the substance of the activity of centers and the growing tendency for their control by authorities; and

(e) frequent change of regulations and organizational forms of science management--which led to feeling that there is no stability and suppressed a part of long-term activity.

It will be recalled that towards the end of the 1970's there were attempts at simultaneous increase of elasticity and greater centralization of the research and development management system. These apparently contradicotry goals were achieved through introduction of product-type [goods and services] systems of research financing and a centralized corresponding network of major research and development programs. The product-type financing of activities in the R&D sphere was supposed to bring them closer to practice and to eliminate bureaucracy in planning and administration. Centralized networks of major research programs were meant to bring about integration of efforts throughout the development cycle and their coordination.

The experiences of the product-type financing proved largely positive. This principle was insufficient, however, to surmount the ministerial barriers and was insufficient to concentrate the research efforts. This occurred primarily because the method of financing and the large R&D programs covered areas of R&D that were too far apart. Extreme limitations of the organizational-unit financing underrated the importance of basic research and failed to overcome bureaucratic influences. Almost one-third of outlays were channeled into R&D for government programs and key problem areas, making their priority apparent but complicating coordination and implementation. At the same time, both solutions discussed here seemed to provide a real possibility of different planning and management of work in unconventional ways, both for scientists and for research managers. Various analyses and discussions usually did not reject these solutions but concentrated on their distortions.

In the 1970's--in contrast to the mid-1960's--practically no management center existed in the nation to provide guidance for the entire science policy. The Committee for Science and Technology stopped functioning in 1972. In later years, its activity was too detailed and too bureaucratic, and, faced with the opposition of ministries, produced little of practical benefit. Equally, the managerial function performed by the Ministry of Science, Higher Education and Technology could not ensure cohesion of scientific policy, because research efforts covered by

government programs were under complete control of the economic-type ministries, each of which independently mapped out the guidelines for research in centers subordinated to them. In the overall scientific policy, a small role was played also by the PAN, although formally it was the "highest scientific institution in Poland" and thus coordinated the priority areas of basic research.

In the last few years, a peculiar mix of activity and management has developed in the control of science in the existing organizational frameworks, operating through financial mechanisms and incentives, as well as administrative orders. The financial mechanisms were of little effect--they did not operate selectively in respect to priority subjects, nor did they ensure complete coverage of the needs, but contained mixed elements of organizational unit and product unit financing. Even less effective were administrative orders that fell apart because of the scatter of decisionmaking agencies. Initially, the Committee for Science and Technology, and then to an even greater extent the Ministry of Science, Higher Education and Technology, lacked sufficient powers and authority and substantial capacity to control effectively the entire scope of scientific research in the nation.

In the face of profound social and economic changes currently under way, we should take a new look at the issues discussed here. New solutions should also be adopted, instead of merely trying to introduce minor improvements into the existing structures, which are not always adequate to the existing realities.

One should thus primarily try to answer the question as to what methods should be used to manage science.

The basic goal in developing a system of R&D management should be to ensure its harmonized evolution in connection with the economy as well as national culture.

Guiding science has its specific nature. The very quality of basic research makes it impossible (in the case of free research) or greatly difficult (with controlled research) to precisely define the directions, implementation, schedule and necessary outlays. On the other hand, the very material limitations call for appropriate planning, organization and management of research. This should occur, however, through creation of optimum conditions for self-management of science. Complete self-management, conceived as independent assignment by goals and methods of activity by scientists, is not possible in the current conditions to be implemented for the entire field of science. One should instead ensure optimum conditions for self-management based on appropriate balancing of internal and external situation in the functioning and evolution of science.

It would be damaging to apply the same criteria to all R&D centers due to the diversity of their nature. They belong, to a greater or

lesser extent, to three basic types of research organizations:

(1) "Disciplinary" research is basic research concerned with subjects mainly decided upon by scientists themselves. The role of superior agencies consists mainly in defining the field of research and providing the necessary facilities. This research is largely financed according to the organization type principle (through appropriations assigned to the research center) from the government budget. These studies constitute the part of the "thinly spread layer" discussed in the analysis of the research strategy above.

(2) "Problem-solving" research is also basic research, but, like applied research, it is directed at solution of specific cognitive or practical problems. The superior agencies in this case define the direction and goal of studies, and scientists define the individual goals and means of their achievement. These studies are financed by the product-type principle (from means appropriated by the coordinator) from the government budget or other centralized sources. The research consists of current priority problems discussed in science management strategy.

(3) "Task-type" research--mainly applied research and development--is financed through contracts signed with particular research centers. These contracts are financed by a contractor directly concerned with the use of the results of research and controling the activity of the staff of the research unit assinged to carry out the work.

Financing of scientific research has been conducted so far differently depending on the type of study. Financial means came from the following sources: interdisciplinary research, from budget or the Fund for Research Work; in problem-solving research, from the Fund for Research Work or the Fund for Technical and Economic Progress; and in task-type research, from the the Fund for Technical and Economic Progress or from the individual enterprises themselves.

Specialized disciplinary research was mainly conducted in higher schools and some PAN institutions, and in 1980 accounted for 8.1 percent of spending in the R&D sphere.

Problem-solving research was conducted in all three spheres. This included the majority of studies at the institutes of the PAN. The share of this research in total R&D was formally 32.6 percent. In actual fact, it was slightly higher because of additional financing from the Fund for Technical and Economic Progress.

Task-type studies were done exclusively by minsterial institutes and development centers. The largest share was financed by the Fund for Technical and Economic Progress, which was responsible for 53.3 percent of R&D outlays (part of these funds were allocated for problem-solving research). Direct participation of industrial enterprises was much lower (6.0 percent).

In connection with the economic reform and the requirements of the scientific community, the mechanisms for financing must undergo qualitative and quantitative changes. Artificial priorities of studies which do not require management through increases of organizational-type financing or increase of disciplinary studies should be lifted. They will remain mostly in higher schools and PAN institutes, which--depending on the type of research--to a certain extent should be financed directly from the budget. This method of financing will also cover the general costs of the above-mentioned centers, such as maintenance of libraries.

Problem-solving research must become the main tool of scientific policy, and its importance should be enhanced. In the area of basic research, this is the only form undertaken in major resereach programs where there is hope of obtaining results of worldwide importance.

The existence of such programs is indispensable to counteract the concentration of facilities on fragmentary and narrow subjects that have an immediate value only within a sponsoring enterprise. They are necessary for coordination of development of the entire R&D sphere on the one hand, and social and economic development of the nation on the other.

No less important is this activity for science in the narrow sense. When concentrating interests of the so-called research and development facilities on narrow subjects, only large research and development programs would be able to meet the needs for basic research results and carry the basic research throughout the entire development cycle.

Maintaining often modified centrally managed research and development programs in the context of the economic reform becomes an objective necessity which ensures success both for the goals of scientific progress and for the broad global interests of the economy, as opposed to the parochial interests of the sponsoring enterprise. Providing the necessary conditions for program competitiveness, the programs should be planned and implemented after completion of basic research based on reliable evaluative studies. This calls for maintaing a portion (some 40 percent) of existing allocations from the Fund for Technical and Economic Progress at the disposal of central agencies.

Task-type studies should be performed in the future on the recommendation of enterprises, but the shift of the centers concerned to self-sufficiency should be gradual, to avoid losses incurred through dismantling of research groups which will not be able immediately to find new sponsors.

The share of outlays in the R&D sphere in the three foregoing types of research could be--excepting the development centers--presented as a first approximation in the following form:

--most outlays on disciplinary research to be financed on the basis of organizational unit should be maintained as a ratio to the share of outlays on problem-solving studies financed on the basis of product-type methods of 2:3;

--outlays on task-type studies should attain an equal amount with those allocated for disciplinary research.

It should be pointed out that the above proportions for distribution of financial outlays do not take into consideration the payments for development centers.

In the immediate future, a destructuring of rearch and development facilities of the economy should be introduced, which will result in transfer into the economic sphere and takeover by enterprises of a number of development centers (especially design and technology bureaus) whose potential should be directed at meeting industrial needs. Large and artificial inflation of research and development in the past decade has not only deprived the development centers of direct links with the production sphere that they serve but also distorted the image of the scale of activity and the means intended in Poland for what is currently referred to as "science." Therefore, eliminating from this sphere the centers that can evolve more appropriately only in an organic coherence with the enterprises will be a premise for proper distribution of society's spending on research.

The question remains as to who will be the controller of the means allocated centrally and what degree of central control of research will be maintained.

Appropriation of means for organization-type financing,that is,for disciplinary research can in principle be conducted through the medium of the ministry to which the centers are subordinated. This is unavoidable, for instance, in higher schools, where the educational and research work are closely intertwined. This is also true of the multifaceted functions of medical academies and their clinics.

Financing of task-type research will be regulated independently according to the interests of the sponsoring enterprises.

It follows from these solutions that central control will be extended mainly over organization-type financing. This covers a wide area of issues, and, as experience shows, would be difficult for one agency to handle. Therefore, we propose dividing the centralized funds into:

1. Fund for Basic Research Research

2. Fund for Technological Progress.

The former would finance selected programs of basic research, with particular attention to priority directions discussed in section I.3. According to the research strategy, the remaining "thin spread" of means for basic research would be obtained through organization-type distribution.

The Fund for Technological Progress would be intended for financing that research and development of a key importance for national development,

along with agriculture and infrastructure of health services. Some of these programs would be included in the comprehensive problems mentioned in section I.3. The remaining funds for centers involved in the advance of technological progress would be received from orders placed by enterprises or regional and central institutions concerned jointly with the ministries. Management of the two funds is important. A purely administrative distribution of means is impossible. It should be linked with coordination. For one thing, most allocations should be based on substantial assessment of the value of current and planned research projects. These functions in regard to basic research and technological progress are different and call for two equipotent, reciprocally complementary, coordinated forces. In this report it is impossible to go into the details of the competences of structures of these bodies; their general concepts will be outlined.

For maintaining the cooperative and representative nature of these bodies, it is assumed that they will be:

1. The Council of the Fund for Basic Research

2. The Council of the Fund for Technological Progress.

It is envisaged that the Council of the Fund for Basic Research will operate with the support of the Polish Academy of Science using the expertise of PAN scientific committees both in specialized questions and as far as general methodology of management of basic research is concerned. The council would use for the current activities the administrative system of the PAN for proper administration of the Fund for Basic Research. The council should be empowered to assess the general state of basic research and priority directions, ensure the favorable conditions for scientific creativity, paths for introduction of scientific results into practice and methods for organizing the work in science. The council would take over the functions of current interministerial commissions for evaluation and coordination of key interministerial problems of basic research.

The Council of the Fund for Technological Progress would be supported in its work by an administrative body created specifically for this purpose, since none of the existing central administrative government agencies are suitable for this function. However, one could consider assigning some of the sectors of the existing Ministry of Science, Higher Education and Technology for these purposes. One possibility is the Committee on Technological Progress, which should be given the authority of a top-level agency of state administration. The role of the council would be providing collegiate guidance to the activities of the committee. The committee would have a basic say in policies on foreign license purchasing, orientation of major technical investment and, especially, charting the main directions of technological advance in the country. The functions of the Committee on Technological Progress will be discussed in section II.6. In matters that have key significance for scientific and

technological policy, the decisionmaking body should be the appropriate committee of the Council of Ministers, headed by a deputy premier and consisting of the minister of higher education, president and the learned secretary of the Polish Academy of Science, and three or four ministers controlling the major spheres of research activity, as well as the chairman of the Committee on Technological Progress. This committee should never be assigned any current operative functions nor "grow" its own administrative apparatus.

The degree and details of coordination should be decided at the level of a center's self-management. This is a complicated problem. At higher schools self-management should be mainly the function of their mode of activity rather than the capacity for financial self-sufficiency. The same is true for institutes engaged in basic research. Self-management becomes a form of activity indispensable for scientific progress. The work of ministerial institutes to a larger degree depends on external conditions--primarily recommendations. The profile of a center--its self-management and self-sufficiency and capacity for financial independence--will become in the nearest future a basic factor differentiating the R&D units. In this context, one should expect different organizational structures that are largely derivative of management methods used.

If the foregoing solutions could favor the concentration of research around key problems of the economy and culture, the direction of their action towards integration of the scientific community is questionable. It seems unlikely that the mechanisms of the economic reform themselves would be conducive to such integration. It is to be expected that they will rather favor further disintegration of communities. Integrative action should therefore be reinforced, such as the work of scientific committees of the PAN, scientific communities, professional journals and their editorial boards.

Scientific policy of the 1960's and 1970's was largely based on the intuition of decisionmakers that essentially had a limited understanding of the regularities governing the extremely complex sphere of the phenomena concerned. Like in other countries, many errors have been committed which should be avoided in the future. An important condition to reducing these errors is creating a system of research in scientific policy which should be coordinated by an authoritative center with strong personnel. The current situation in Poland greatly deviates--in the negative sense--from that in other socialist countries.

2. Scientific Personnel

Towards the end of 1980, the number of employees in scientific research, development and higher educational institutions* totalled 357,500 (compared

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*To avoid discrepancies in the methods of evaluation as to what portion of higher school employees should be counted as working in the R&D sphere,

[cont'd]

with 332,700 in 1970 and 414,800 in 1975). Following a period of rapid growth of employment between 1971 and 1975, a decline set in. The cause was mainly reorganization of a group of development centers (mainly the so-called assigned centers), leading to a reduction of employment in the research sphere by some 60 thousand individuals within five years. The structure of employment in 1980 by type of institution is shown in Table 1.

Table 1. Employment Structure in 1980 According to Type of Center

	Number of employees, thousands	Share %
Total R&D sphere	357.5	100.0
including:		
Research and development centers	146.2	40.9
including		
--ministerial-branch institutes	73.2	20.5
--PAN centers	12.2	3.4
--other research and development centers	60.8	17.0
Higher schools	133.8*	37.4
Development centers	77.4	21.7
including:		
--specialized	28.8	8.1
--enterprise facilities	48.6	13.6

*Total number of employees in higher schools. In the government statistic data on "Scientific Research and Development Centers--1980," which includes only selected categories of higher school employees, the number is cited as 76,700, while the total number of employees in research and development is given as 300,300.

data in this report cover complete employment in higher schools.

In the R&D sphere, in addition to higher schools, the group of research and development centers include: ministerial and specialized institutes, PAN centers, R&D centers, central laboratories, science service centers; in the group of development centers: specialized centers, centers of enterprise facilities and centers of development service. Three spheres of institutionalization of science are distinguished in addition to the foregoing classification: higher schools, centers of the PAN and minsterial-specialized centers. The statistics of science are not available in practice for all types of centers. This creates inconveniences and makes comparative analysis difficult.

The employment of highest qualified personnel--scientific workers--in late 1980 totalled 70,100 (compared with 39,600 in 1970 and 60,500 in 1975). In this group of workers the last five years thus witnessed an increase, although at a far slower pace than in the preceding five-year period (an average annual growth of 3% against 9% in 1971-75).

In 1980, centers of research and development, together with higher schools, employed 11,700 professors and docents (compared with 8,100 in 1970).

In the five years between 1976 and 1981, 18,800 persons were awarded the doctoral degree and 2,900 the degree of doctor habilitatus. At the same time, 1,678 were awarded the title of associate professor. However, this did not increase substantially the proportion of people with highest qualifications or doctoral degrees compared with the total number of employees in science.

With periodic fluctuations, the total employment continued to grow, as well as the number of research workers in higher schools and in three major groups of research and development centers--namely, ministerial institutes, research and development centers, and centers of the PAN. The number of scientific workers in 1980 was: at PAN centers 122%; at ministerial institutes 112%; at research and development centers 158%; at higher schools 116% compared with 1975.

The growth rate of employment in the R&D sphere greatedly exceeded that of the technological base, modern equipment, etc., which resulted in an underutilization of the existing potential of qualified personnel. In the conditions of the incipient economic reform, due to temporary weakening of interest on the part of enterprises in innovation, the potential could for a time remain "unemployed," giving rise to a new problem: retention of the basic research cadre.

Finally, it should be pointed out that maybe for the first time in postwar history further development of research centers would proceed in an unfavorable social climate. Wide participation of representatives of science in the government organs, in consultative bodies, in groups approving economic initiatives that failed, and, finally, among the popularizers of the so-called success decade--created an attitude of disappointment and reluctance vis-a-vis the scientific community. There has grown a conviction--partly justified--that there are too many people in Poland engaged in science compared to any tangible economic results of the work and that the responsibility for this situation lies mainly with the scientific community.

The structure of employment describing the main type of personnel in the R&D sphere is shown in Table 2. These data indicate clearly the differences in the employment structure depending on the type of research center. These differences confirm the additional information on the participation in working groups of individuals with scientific degrees and titles. In 1980 the proportion of this category was: at centers of the Polish Academy

Table 2. Employment Structure in Scientific Research Centers, Development Centers and Higher Schools as of 31 December 1980 (percent).

Type of center	Total employ-ment	Scientific workers	Other teachers and faculty	Engineers and tech-nicians with college degrees	Engineers and tech-nicians without a college degree	Other workers in the main sphere	Adminis-trative and service personnel
1. Centers of the PAN	100.0	37.2	-	14.4	16.7	10.9	20.8
2. Ministerial scientific research institutes	100.0	19.7	-	16.1	26.9	19.3	18.0
3. Other scientific research centers	100.0	5.4	-	25.4	26.1	27.1	16.0
4. Development centers	100.0	1.4	-	30.7	34.1	28.6	5.2
5. Higher schools	100.0	34.9	7.4	8.6	10.5	6.9	31.7

*Note: Base of calculation: 1-4 Government Statistics Office, Placowki naukowo-badawcze i rozwojowe 1980; 5 Informator-szkolnictwa wyzse (MNSzWiT, 1981).

of Science 26.6%, in higher schools around 23%, in ministerial institutes 7.4%, in other scientific research centers 1.75% and in development centers 1.2%.

These differences are largely justified by the nature of the work conducted by the respective centers. In correspondence with these differences, different requirements as to the scientific qualifications should be laid to major groups of research workers (creative personnel) in individual types of centers.

The greatest similarity is seen--and rightly so--between the centers of the PAN and higher schools.

A basically different group consists of development centers and the category indicated in the table as "other ministerial scientific research centers" (excluding the institutes--namely, research and development centers, central laboratories, experimental enterprises, etc.). By the type of work and by ministerial subordination, these are mostly highly specialized technical centers that normally do not engage in basic or applied independent research. For this reason, different criteria should be applied to their personnel (in selection, evaluation, training, certification, rotation and promotion) than when dealing with the scientific centers of the PAN or higher schools. These criteria should in fact be brought nearer to those used in reference to engineers and technicians in the industrial sphere.

The last group are ministerial scientific research institutes, which embrace a broad spectrum of scientific disciplines and carry out studies on a variety of subjects. The subdivision of their research personnel into scientific researchers and engineers or technicians with higher education is not always justified by the substance of work, but frequently based on formal or salary-related criteria. For proper implementation of the tasks of these centers, the research personnel should have both high scientific qualifications and professional production experience. Using different promotion criteria than those applied in PAN or higher schools when dealing with management of research units is not only justified but necessary. This, however, should not result in different requirements for personnel of these centers when they apply for "traditional" degrees or scientific titles. However, since the main subject of discussion is the community of scientific workers, some of these phenomena may prove untypical or not completely applicable to groups of engineers and technicians in research and development facilities of the economy.

Data on the structure of employment of scientists classified by professional groups are given in Table 3. Information on the structure of employment by age of scientist is given in Table 4.

Whether these employment numbers and the characteristics of personnel (qualifications, age, etc.) are adequate to the needs of science and fill the requirements of the economy, culture and the economic potential

Table 3. The Structure of Employment of Scientists by Education Specialty --31 December 1980 (calculated on the basis of data from "Magister")

Professional group	Percent
Total	100.0
Engineers in technical professions	33.3
Managerial and administrative personnel in administration and economy	0.3
Engineers in agricultural industries and veterinarians	5.2
Exact science specialists	20.2
Specialists in medicine, stomatology and pharmacology	12.2
Specialists in the humanities, history and social sciences	10.2
Specialists in political science, labor studies and economics	9.2
Educationists, teachers and coaches	5.8
Librarians and scientific and technical information workers	0.7
Specialists in arts and culture and cultural education	2.2
Other professions and specialties	0.6

of the nation--has been a subject of controversy for years. There are not even approximate methods for evaluating the employment relationships between the spheres of science and technological development on the one hand and other branches of the economy on the other.

This suggests using expert judgment, which has a limited accuracy.

The extent to which the actual quantitative growth of the personnel deviates from what was required several years ago at the Second Congress of Polish Scientists as the desired level is indicated by the estimates of required employment (ultimately through 1990) made in 1980. The total employment in the R&D sphere attained 57 percent of that figure, and employment in the category of research scientists 79 percent. Thus, not only was there no required growth, but conversely, the improvement in the employment structure through a larger share of service and assistance personnel has been reversed.

A certain image of the current situation in Poland as compared to other socialist nations is given by the information indices in Table 5. Judgment based on so-called international comparisons, however, in view of the different extent of the R&D sphere and its different organization patterns in different nations (including socialist countries--for instance, as regards the proportions of participation of the academies

Table 4. Employment Structure by Age and Position--31 December 1980 (calculated on the basis of data from "Magister" system).

Position	Total number of employees = 100%	Including share of individual age groups, %									
		under 29 years	30-24 years	35-39 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	over 64 years	Mean (median) years
Full professors	1,196	-	7.4**	3.0**	2.0	4.0	11.4	18.1	16.2	37.9	61
Associate professors	2,520	-	0.4	0.4	2.0	9.7	25.6	28.3	15.6	18.1	57
Docents	7,595	-	0.4	2.1	8.7	18.1	28.2	23.8	10.5	8.6	48
Adjuncts*	15,403	0.5	14.7	29.2	24.7	14.3	8.9	4.5	1.1	0.2	40
Assistants and senior assistants	23,701	28.5	49.2	16.9	4.1	0.9	0.3	0.1	0.0	0.0	32

*Data only available for higher schools.

**Errors in the data base of the information system are likely (age too low).

of sciences or development centers) does not provide completely creditable evaluations Poland considered in comparison to six socialist nations holds the fifth place (following the USSR, GDR, Czechoslovakia and Bulgaria), preceding only Hungary. Similar data for the industrialized capitalist European nations indicate lower figures than what is observed in Poland. For instance, the number of scientific workers per 10,000 population, which includes scientists as well as engineers with higher education, was in 1977 in Poland 26.2; in FRG 18.7; in France 12.8; in the United States the index was in 1978 26.2, that is, it was similar to the Polish level.

Table 5. Characteristic Indicators of Employment in the R&D Sphere (employment per 10,000 population).

Nation	Annual statistics CEMA	Other sources of CEMA	
	1978	1978	1975
	Altogether in the section "Science and scientific services"	Scientists	Scientific workers with learned degrees and titles
Poland	43.1	19.3	9.1
Bulgaria	66.9	22.8	5.7
Czechoslovakia	108.4	38.7	10.4
GDR	68.0	39.4	16.8
Hungary	21.5	35.7	3.6
USSR	157.2	50.8	13.9

Calculated on the basis of annual statistical yearbook of CEMA, 1980, Rocznik Statystyczny GUS, 1980. Unpublished statistical data of CEMA.

The experts reports of the science committee prepared in the past few years have shown that in optimum conditions for Poland -- for maintaining the proper age structure of science personnel--a five percent annual growth of employment in this category is desirable, accompanied by moderate selection from the existing work force. Because of the economic difficulties the indicator adopted for the 1980's was three percent. An overly high indicator will lead to loosening of the selection criteria; an overly low indicator will limit the potential influx of young talented college graduates to research centers, which, after some years, will produce undesirable disruptions in the labor force pattern. Stopping or weakening the selection

process--observed in the last few years (confirmed among other things by the poor quality of doctoral theses)--deeepened this deformation.

In 1980, the mean ratio of adjuncts to assistants or senior assistants approached 1:1 (according to the "Magister" information subsystem, this ratio in institutions of the PAN was 1:0.8, and in ministerial institutes even 1:0.65). A young scientist without a doctor's degree has become in many centers and departments an "endangered species," a shortage badly felt in certain types of research.

Table 6. Changes in the Employment Structure among Academic Faculty According to Positions in 1970-80 (percent).

Year	Total	Professors	Doctors	Adjuncts	Senior assistants	Assistants & assistant trainees	Others	
1970	100.0	4.7	12.7	20.7	28.7	11.6	20.6	
1975	100.0	4.8	10.7	23.9	29.3	16.1	15.2	
1980	100.0	5.2	9.6	33.4	25.8	11.1	14.9	
	175%	159%	132%	283%	158%	168%	127%	Employment number gross index: 1970 = 100%

For a number of years, a relative decline of the assistant personnel (engineers, technicians, and administrative and service personnel) as related to the number of scientists has also been observed. In higher schools and PAN centers, these proportions deteriorated during 1976-80 by some 20 percent. Finding skilled workers in this category and keeping them at a research center is becoming ever more difficult because of the wage rates.

With these two tendencies the relatively simpler jobs have to be done by highly skilled personnel, lowering the degree of utilization of qualified workers and interfering with proper organization of work.

The last five years have also brought unfavorable changes to the financial situation of scientists. Mean salaries in the category "science and technological development" in 1981 were 98 percent of the mean wages in socialized economy (in 1970 the number was 122 percent), while wages in higher education were 105 percent (compared to 118 percent in 1970). Since the mean qualification level of scientific personnel has risen in the meantime, the situation appears to be even worse. This is a result of the fact that the wage rates of scientific research centers have not been revised since 1976. Salaries of most young scientists (assistants, senior assistants and even some adjuncts) are currently below the mean wage in the socialized economic sector.

An unfavorable influence on selection of young people to work in science is also exerted by housing shortages. Originally, research centers and also, even though to a lesser extent, high schools were mostly concentrated in urban areas. Assistance with housing for scientists, a question that has not been addressed for years, especially as regards employees of the PAN and higher schools, limits the contingent for selection to urban residents and higher income social groups. However, even for these young people their low salaries for their early (approximately 10) years of work make it practically impossible to find a private apartment. At the same time, surveys among scientists indicate that, because of difficulties with space in a great number of research centers, a large proportion of research is in fact conducted in private apartments, frequently at night when this work does not clash with the occupations of other members of the family.

Scientific progress and enhanced social and economic effects of science largely depend on the attitudes and views held by the scientific community. The scientific community is a group of people linked by common convictions concerning the importance of knowledge and the paths leading to verified reliable information--one should therefore be worried about facts evidencing decay, changed loyalties and controversies in the area of moral standards by which the members of this group are governed. Concern for one's personal career, instead of contribution to the progress of knowledge, criticism aimed at persons instead of errors in research or statement of results are often cited as indicating a loss by the scientific community of its capacity to control the conduct of its members. Bringing to light the forces and capacities of the scientific community requires giving it a fair and true partnership in situations affecting the vital interests of each scientist. These vital interests include establishing the principles of joint work between scientists and other professionals; improved forms of this cooperation; choice of functions and definition of relationships; the search for criteria of social value of the mission of a scientist who is a citizen of the socialist state. Too often the authority in this area was entrusted to scientific institution and its official leadership. Among other things, opportunities should be provided for young people entering science and now stepping onto the road of independent research to take part in decisionmaking that affects the structures of scientific life.

As we have pointed out, unfavorable phenomena that occurred during the past few years in the nation's life did not leave undamaged the sphere of scientific activity. There were tendencies for "showcase" endeavors in science, raising the prestige of individual institutions and groups through premature scientific advancement of their members; instead of support of scientific criticism--there were cases of its suppression, etc. These phenomena could not leave unaffected the attitudes of certain scientists--undermining the ethical standards in science and the principles of substantial evaluation of research results. This made it possible for individuals engaged in "sham science" to prosper in "science," while offering no real creative contribution and also--sporadically--hampered the growth of younger investigators, those likely to become unwelcome competitors.

It must be acknowledged that in that area the leadership of higher schools and research centers for many years failed to act with stability, consistency and courage. The ills were exacerbated in the past two years by reluctance towards a system of regular evaluation as an efficient principle to transfer those doing no creative work to other jobs--which would be fully in line with the relevant laws. The problem of evaluation of scientific workers in higher education was resolved by extending to the category of adjunct the rigors of temporary employment. There were even proposals to introduce similar principles with respect to assistants, senior assistants and adjuncts in other spheres of science. This concept, adopted in the draft state in higher education, is supposed to operate in combination with the system of evaluation being prepared and bound to expose inconsistencies of the individual concerns, as well as complete lack of creativity of certain persons holding the highest positions in the scientific hierarchy.

Since in the coming years (in the sphere of science as well) one must reckon with limited rates of growth of employment in various fields (and sometimes with its stabilization or even reduction), it becomes a primary task to ensure an influx of young talented scientists. An indispensable condition for this is more efficient selection and dismissal from research centers of workers who fail to attain adequate results in their activities.

Overcoming these negative phenomena and their aftermath is most important for the development of Polish science. Because of the absence of objective and measurable criteria for assessment of the value of scientific work it will face major difficulties. It must be clear, however, that assessment of the scientific community can be more adequate, less subjective and less susceptible to non-scientific influences than the individual opinion of even a most renowned expert. Giving more attention to making the assessment processes a collective function is essential. This involves, above all, improved circulation of scientific information.

An early change of the principles of domestic trial employment periods and provisions in this system for regular periodic exchange of novice scientists between basic research centers and development centers is a necessary change in personnel policy. This could greatly contribute to the conjugation of various types of research.

Heated debates in the last several months about the situation in Polish science concern also issues that belong to personnel policy. The causes of difficulties, however, are mainly outside the community -- the sets of external factors operating either directly or through the medium of supervisory and coordinating organizations, determining the activities of research centers and the course of life in science. This refers primarily to procedures of promotion to higher levels in the science hierarchy, to positions in science management, and the possibilities for foreign trips by scientists. The negative phenomena cannot be attributed solely to the lack or limitations of self-management of the scientific community, so that an increased self-management cannot be expected to automatically

do away with many of the unfair practices. Whatever the opinions concerning the activities of such groups, as, for instance, the Central Qualification Board (for instance, the impossibility of defense through scientific discussion when forbidden by the Central Qualification Board), it should be noted that almost all (with few exceptions) awards of professorships and all matters concerning granting of scientific degrees were based on suggestions and recommendations of local groups of scientists (scientific or specialized councils). Some of these basically self-governing bodies addressed some of the issues too superficially without proper criticism when awarding a scientific degree or title and adopted objectionable resolutions. Calls for eliminating supervision of the observance of proper criteria and competence level do not, therefore, seem justified. This control would limit the number of groups authorized to award scientific degrees and titles. Requirements for quantitative and qualitative characteristics of science bodies should be more stringent than at present. Besides, the CQB or a proper public control agency should more often withdraw or suspend the authority from those bodies whose practices deserve criticism. This would mean a shift of accent in the work of such agencies as the CQB from examining decisions on individual cases to comprehensive evaluation of proper practices of scientific councils.

Criticism of the system of scientific degrees, titles and positions--much more elaborate and formal and less flexible than in most European nations--failed to produce the expected effect on the progress of science in Poland. It also proved little-effective in selection of personnel in terms of ethics, involving major social costs due to time-consuming formal procedures engaging a great number of scientists and at the same time perceived as a system that could be used for unsubstantial assessment and personnel manipulations. In this context, proposals were made in the discussions,suggesting abolition of one of the professorial titles, gradual transition to time term employment at positions of docents and professors and limiting the system of academic degrees to one degree--the doctor of science. Whenever the first two suggestions are criticized, this is done in terms of maintaining the status quo--the tradition,that is,formal rather than substantial objections. Views on the third issue, because of the deterioration of the quality of doctoral theses in the past few years, especially in the basic sciences, are premature, if not altogether wrong. As a most appropriate solution, there is a proposal to retain the degree of doctor habilitatus, which, however, should be awarded on the basis of contribution to science--omitting the requirement of presentation of an elaborate special thesis. Some actions in this direction are allowed by the relevant legal statutes; it is desirable, however, to turn these exceptions into an obligatory principle.

3. The Material Base of Science and Investment Outlays

The total worth of fixed assets of scientific research and development centers and higher schools in 1980 prices was 108.9 billion zlotys, including 36.1 billion zlotys (or 33 percent) of the value of research equipment. Half of these equipment assets were acquired in the five

years between 1976 and 1980. Basically, this proportion seems correct, although major mismatches between centers are observed. Centers also have so-called "special scientific research equipment" purchased for implementation of specific tasks and not counted among fixed assets until completion of the project. The value of this equipment in 1980 totalled 7.4 billion zlotys.

Table 7. Distribution of Fixed Assets and Equipment by Type of Center.

	Fixed assets value, billion zlotys	Share, percent	Equipment value,* billion zlotys	Share, percent
Total R&D sphere	108.9	100.0	43.5	100.0
including:				
Scientific research centers	43.1	39.6	18.2	41.9
including:				
--ministerial-branch	39.0	35.8	15.8	36.4
--PAN	4.1	3.8	2.4	5.5
Higher schools	45.2	41.5	20.0	46.2
Development centers	20.6	18.9	5.2	11.9
including:				
--specialized	10.6	9.8	1.6	3.7
--enterprise facilities	9.9	9.1	3.6	8.2

*Includes both equipment counted among fixed assets and special equipment.

As seen from these data, ministerial institutes and higher schools carry most assets; the latter, however, use the equipment and facilities for educational purposes as well. It will be possible to assess these data if viewed against the background of the entire economy and put into a development perspective. Because of heterogenous statistics for 1970-80, only data for scientific research centers were taken for comparison. In the 1971-80 decade, the state of the material base of science compared to the background of the national economy underwent drastic deterioration; this is true both of fixed assets and its equipment component. The relevant data are given in Table 8.

While the value of fixed assets per employee in 1970 was equal in scientific research centers and industry, in 1980 it fell by one half. This means that the building of the research base fell behind the industrial development, reducing the innovative potential of research centers. Even

Table 8. Comparison of Gross Value of Assets per Employee in 1970 and 1980 (current prices, thousands of zlotys).

	1970				1980				Growth indicators, 1970 = 100%	
	Fixed assets		Including: machines, equipment & apparatus		Fixed assets		Including: machines, equipment & apparatus			
	Value	Percent	Value	Percent	Value	Percent	Value	Percent	Fixed assets	Including machines, equipment, & apparatus
Socialized economy	267.7	100.0	47.9	100.0	499.3	100.0	126.8	100.0	186.5	264.7
Industry	231.8	86.6	94.5	197.3	521.4	104.4	235.7	185.9	224.9	249.4
Scientific research centers*	205.5	76.8	58.9**	123.3	290.5	58.2	93.2**	73.5	141.4	158.2

*Excluding higher schools and development centers.

**Only equipment counted among fixed assets.

Calculation based on data from GUS Statistical Yearbook.

in the relatively better period, research, unlike in many other countries, lacked a strong experimental base, and the situation further deteriorated in the mid-1970's. In addition, there was aging of fixed assets, as illustrated by utilization degree* and period of recovery** of these properties.

Large deviations from mean values were observed in particular in some ministerial institutes. The renovation rate was satisfactory, while in PAN centers equipment utilization rate attained 70 percent.

Table 9. Aging of Fixed Assets.

	1970		1980	
	Renovation period (years)	Utilization rate (%)	Renovation period (years)	Utilization rate (%)
Socialized economy	14.5	38.2	10.5	34.0
Industry	11.8	40.5	11.2	36.4
Scientific research centers	11.0	35.8	16.0	46.4

We thus see that while national assets, especially in industry, were renovated in the 1970's, the situation in research deteriorated. Almost half of the equipment of science, which is supposed to be at the forefront of advances, sustained physical wear and tear or became obsolete.

The situation with accommodation space of scientific research centers is particularly difficult; disproportions with the socialized economy are drastic, as seen from the table.

Table 10. Value of Buildings and Structures per 1 Employee.

	1970		1979	
	Value thou. zlotys	Percentage	Value thou. zlotys	Percentage
Socialized economy, total	186.2	100.0	281.1	100.0
Scientific research centers	79.4	42.7	98.8	35.0

*Utilization degree is the percentage expressing the depreciation from the time a building or piece of equipment is put into operation to the gross worth (i.e., incurred costs).

**Recovery period--inverse ratio of investment outlays in a given year to value of fixed assets in the previous year.

In research and development centers (without higher schools), in 1975 (later data are absent) there was 13.1 m^2 of building surfaces per one employee, which, compared with 1976, was a reduction of as much as 2 m^2. The situation was the worst in PAN centers, 12.9 m^2--and there are centers (for instance, the Institute for Information Science Principles or the Mammal Research Institute) with just 5 m^2 per one employee.

Of particular importance for science is the size and facilities of library space; deplorable data in this area contained in the report of the State Library Council prepared six years ago have further deteriorated, giving added urgency to the recommendations of the report.

This situation results from many years of neglect in capital investment into the R&D sphere. The amounts of investment were decided by accidental negotiations and never correlated with the investment dynamics of the economy. As is well known, in the first half of the 1970's the proportion of capital investment to the national income was growing: in 1970 it was 27.2 percent, while in 1975 it grew to 34.2 percent; only from 1978 there was a decline to 26 percent in 1980. The distribution of investment outlays in 1980 by type of center is given in Table 11.

Table 11. Distribution of Investment Outlays in 1980 by Type of Center.

	Investment outlays, billion zlotys	Share (%)
Total R&D sphere	4994	100.0
including:		
Scientific research centers	2098	42.0
including:		
--ministerial-branch	1912	38.3
--PAN	186	3.7
Higher schools	1903	38.1
Development centers	992	19.9
including:		
--specialized	428	8.6
--enterprise facilities	564	11.3

It is true that investment into research and development grew between 1970 and 1976, but it did so at a slower pace than in the economy as a whole. In 1970, outlays on scientific research centers (without higher schools and development centers) totalled 1.8 billion zlotys, attaining its maximum of 4.4 billion zlotys in 1975; since 1976 there was a decline down to

2.1 billion zlotys in 1980. These data are given in current prices, so that the real value decline (in view of the price rises) is even greater.

The ratio of investment outlays per one employee in this group of scientific research centers and in the entire socialized economy appears as follows (current prices):

It appears objectionable that, in a state striving towards high development and modernization of its economy, the research base that is supposed to support this progress was afforded just one-third of the means per employee of the amount allocated to routine production activities. In many countries the ratio is inverse. This suggests that R&D investments should be at least five times the present level.

This requirement in our present condition is of course academic, but another indicator has to be met fully, even under the most difficult economic conditions. This is stopping the devastation of national property in science. Based on an analysis of the degree of amortization of individual components of national property, one can approximately say that, for fixed assets in R&D, depreciation write-offs should be an average of 10 percent. For higher schools, because of a faster rate of utilization of equipment for educational purposes, a depreciation of 15 percent would be in order. Total amortization costs would be 13.2 billion zlotys in 1980.

Centers at enterprises should be treated separately, for investments in this area are difficult to separate from investment in industrial enterprises.

Table 12. Ratio of Investment Outlays per 1 Employee in Scientific Research Centers and the Entire Socialized Economy.

	Thousands of zlotys	Percentage	Thousands of zlotys	Percentage	Growth indicator, 1970 = 100%
Socialized economy	18.6	100.0	44.6	100.0	239.8
Industry	19.7	105.9	43.9	98.4	222.8
Scientific research centers	18.5	99.5	17.3	38.8	93.5

Calculation based on data from GUS Statistical Yearbook.

The numbers given here should be considered the necessary minimum of investment outlays into science to ensure the minimal conditions for progress. Traditional investment of some 5 percent of the total worth in excess of depreciation would be required that would amount to an investment outlay of 18.6 billion zlotys annually in 1980 prices.

Considering the investment for the needs of science, one should bear in mind the proportions concerned. In 1980 total investment in socialized economy was equal to 536 billion zlotys, while in the R&D sphere it was equal to just 0.93 percent of total investments, which means that basically it was marginal element of investment policy of this state. While a 100 percent increase of this investment would mean a drastic qualitative change of the situation of Polish science, on the national scale that would mean an increment of less than 1 percent.

Supplying science with scientific research equipment should be considered separately and in greater detail. This involves domestic production capacities, equipment purchases abroad and methods of effective utilization of available research potential.

In 1978, scientific research equipment of a total value of 4.6 billion zlotys was produced inside the country. Imports of equipment during the same year amounted to some 3 billion zlotys, including 59 percent from socialist countires and 41 percent from capitalist countries. In 1980 the imports were slashed to 1.7 billion zlotys.

A part of domestic research equipment is exported to many countries. In 1978 the worth of these exports was 1.2 billion circulation-type zlotys (114 million foreign-exchange zlotys). Of this quota, the first payment area (socialist countries) accounted for 70 percent, and the second payment (capitalist countries) accounted for 30 percent.

Equipment available in domestic markets is purchased both by scientific centers and by laboratories at industrial enterprises and other institutions subordinated to various ministries, such as epidemilogical stations. It can be said approximately that research and development centers--including higher schools--received at most one half of all scientific research facilities.

The main domestic suppliers of measurement and research instruments are enterprises grouped as follows (share of supplies, data for 1978):

Enterprises of the Ministry of Metals and Machinery	approx. 63%
Ministry of Science, Higher Education & Technology	approx. 10%
Polish Academy of Science	approx. 8.7%
Ministry of Power, Engineering & Atomic Energy (prior to separation of nuclear committee)	approx. 7.5%
Working cooperatives	approx. 7.2%
Others	approx. 3.6%

Overall, there are not more than 40 plants producing this equipment. Employment at these plants in 1978 totalled about 16,500 workers. Until now, the situation has remained the same. Most enterprises employ less than 500 people.

Over 60 percent of equipment is produced by enterprises belonging to the Ministry of Machine Industry. This is mostly general purpose and electronic measurement equipment (voltmeters, generators, oscilloscopes, etc.). Sophisticated specialized scientific research equipment is mostly produced by small enterprises belonging to the Ministry of Science or the PAN.

The technical level of operators is disparate and frequently trails the world state of the art. Mass-produced research equipment in the country is still below the level of production in industrialized nations, both in terms of nomenclature and quality. However, prototypes or smaller series produced in research institutes sometimes attain a very high level.

Improved supply of equipment to research units can be attained through development of domestic production facilities. It should be considered that scientific research requires a broad nomenclature of measurement and research equipment. It would be wrong, however, to try to produce domestically all or even a large portion of equipment types--that would mean a scatter of personnel and funds. Even the largest nations are not self-sufficient in this area. Efforts should be concentrated on spheres where specialized experienced groups already exist. Improvements should be made in well mastered areas to ensure world-level quality and export of the finest products. The foreign exchange obtained in this manner should be used to purchase modern elements and assemblies or equipment units unavailable on the domestic scene. The so-called "foreign-exchange input," although needed for domestic equipment production, is not large and does not exceed 10 percent.

An optimum solution would be small specialized enterprises affiliated with research units and grouping most skilled professionals in the field concerned. Scientific research equipment--unlike, for instance, broad purpose measurement equipment--should not only be devised but also made by highly skilled cadres of personnel and cannot be successfully manufactured by means of routine industrial techniques. In industrialized nations equipment of the highest level of sophistication is produced in precisely this fashion.

Foreign exchange outlays, included in total investment outlays into science and formally contained in the total figure given above in zlotys, are spent mainly on import of modern equipment from abroad. The value of equipment purchases abroad in 1980 was 1.7 billion circulation-zlotys. This amounted to 9.4 percent of the value of equipment purchased during the entire five years from 1976 to 1980. This means a virtual decline of scientific research import equipment by 50 percent. In the current situation, further drops in this already modest quota may prove unavoidable. In this context, most important becomes the purchase of replacement parts and auxilliary materials for already operative foreign equipment so as to at least maintain operability of units purchased abroad in previous years. It is necessary to break down the bureaucratic habits of foreign trade centers and introduce administrative regulations to simplify the mechanism of this cheapest but vital import activity. In particular, a possibility should be provided for buying smaller parts and materials, bypassing the central foreign trade agencies; for instance, directly by institutes from their own foreign ex-

change accounts, or directly by scientists on foreign trips. This would be less expensive than acting through central agencies and at the same time would ensure error-free purchases.

In scientific centers involved in experimental research, the principle should be introduced that would limit the number of personnel to the equipment's potential. This would affect the personnel policies of these centers. On the other hand, the utilization of unique research equipment sometimes leaves much to be desired, because centers do not have personnel for continuing service maintenance of the equipment, which could be used by outside customers as well. For this reason, it is highly desirable to reactivate or create community laboratories. Such laboratories for cooperative use of valuable equipment developed rapidly in 1972-74, but in later years experienced a major drop-off. In a comprehensive analysis in 1977, a positive assessment was given to the work of these laboratories; no practical steps, however, were taken at that time to reinforce them. In the current conditions, community laboratories would operate on different principles than as provided for earlier. There is a need to take into consideration the consequences of the economic reform for the majority and the research requirements of possible outside clients of a laboratory. Forming research laboratories on a community basis should be closely linked with regional planning and centralized financing of purchases of expensive research equipment.

4. Outlays for Scientific Research

Outlays for scientific research embrace the investment outlays discussed above and current outlays which comprise in particular wages, fees, material costs, operating costs and maintenance costs for equipment and buildings. In Polish statistics, both kinds of outlays are separated, although in total analysis of outlays for science they should be considered together, as is done in international statistics.

The breakdown of current outlays (current costs) by type of center appeared in 1980 as follows:

In view of the heterogeneous statistics available for estimating the dynamics of science, we were confined to data on scientific research centers. Annual current outlays in this group experienced a 3.8-fold growth between 1970 and 1980. This was largely due to controversies in substantive terms, inclusion of "research and development centers" into this group, which mainly were created on the basis of development units.

The current costs per employee in scientific research centers were in 1970 equal to 80,300 zlotys and in 1980 152,200 zlotys--that is, a growth of 1.9 times. This growth occurred mainly in the five years between 1971 and 1975; in the subsequent five-year period, the annual growth was half of that of the previous period and hardly covered the growth of wages and prices. The limitations affected most badly experimental research, where, because of expensive materials such as chemical agents and laboratory animals, the current costs per employee are several times those of the mean value.

Table 13. Breakdown of Current Costs by Type of Center in 1980.

	Quota, million zlotys	Share (%)
Total R&D sphere	40,519	100.0
including:		
Scientific research centers	22,524	55.6
including:		
--ministerial-branch	20,206	49.9
--PAN	2,318	5.7
Higher schools	8,020	19.8
Development centers	9,975	24.6
including:		
--specialized	3,547	8.8
--enterprise facilities	6,428	15.8

During the course of this decade, inconsistencies in the policy of financing were observed. In the 1970's, centralistic tendencies prevailed, so that the percentage of finances into the R&D sphere from the budget grew from 24.4 percent in 1970 to 50 percent in 1973. However, from 1976 the situation stabilized, and there was a small decline of budget share from 47.2 percent in 1976 to 40.2 percent in 1980, which, however, was a far cry from the prevalent R&D financing by enterprises, as was the case in the 1960's, and should be considered the proper procedure. Another phenomenon was the gradual centralization of means around government programs, which in 1980 accounted for 12.6 percent of total R&D spending.

In international comparisons of research and development, two characteristics are commonly used:
--per capita annual R&D outlays; and
--share of R&D outlays of the national income.
Both groups of indicators can be viewed as approximate measures because of the differences in the methods of evaluation of national income and of the outlays themselves, as well as differences in the definition of the R&D sphere.

Annual outlays on R&D (per capita) varied in a wide range. In the group of industrialized nations, the figures (in 1978) were as follows (U.S. dollars):

USA	$233.7
FRG	221.7
Holland	210.8
France	154.8
Japan	154.8

In 1973 the mean figure for non-OECD member countries was $87.6, with the world average--including developing nations--being some $26.

For the CEMA nations international statistics for 1973 gave a quota of $85.0 annually, which, however, seems overestimated because of the official rate of dollar exchange. In Poland, R&D outlays (excluding higher schools) in 1980 were near 1,300 zlotys. It is likely that the real per capita outlays on R&D in Poland were at the level of developing nations.

Most commonly, spending on science is expressed as percent of the national income. In 1975 the share of research and development in socialist countries was as follows:

USSR	4.8%
Czechoslovakia	3.9
GDR	3.8
Hungary	3.5
Bulgaria	2.4
Poland	2.3

Advanced capitalist countries in the same year had the following figures:*

USA	4.6%
FRG	3.8
Japan	3.2
Great Britain	3.1
France	2.7

In Poland, compared with national income, current costs in 1980 amounted to 1.99 percent, and, together with capital investment, 2.23 percent. This was the lowest figure among socialist nations. Since then, the share of spending on science in the national income of other socialist countries experienced a growth tendency. In Poland, however, it started on a downturn.

Because of the disruption of investment outlays, the ratio of investments to current costs has fallen in Poland below the level of socialist and capitalist countries. This is seen from the following comparisons (foreign data for 1976) of the percentages of investment to total R&D costs:

Bulgaria	17.2%
Czechoslovakia	15.4
Hungary	18.1
Rumania	21.6
Poland	10.9
France	10.4
FRG	12.8
Belgium	17.6
Austria	18.6

*Recalculated considering different methods of evaluation of national income, cited from "Perspektiwy razwitija NTP stran-czlenow SEW do 1980 goda" (Moscow, 1977).

This means that in Poland extensive research was conducted, whereas there were no facilities for intensive development of experimental studies. In the current situation, unfortunately, one has to be reconciled often to this state of affairs, for it ensures "maintaining" the valuable scientific cadre and opens prospects for its future better utilization.

As has been shown from whatever viewpoint, we are in poor shape in regard to outlays for scientific research. In the current situation, of course, no drastic changes can be expected, especially since the growth of personnel limits the weak material base of Polish science. In view of this fact, and, on the other hand, assuming the minimum 3 percent personnel growth in science, an increase of material supplies of 8 percent annually would be required to maintain the modest level of experimental research; we arrive at the following projected estimates of current outlays on R&D in 1980 prices:

Current Costs, 1981-85 (billion zlotys)

1980	40.5
1981	42.7
1982	45.0
1983	47.6
1984	50.0
1985	53.2

Obviously, economic difficulties may lead to further budgetary cuts, but it should be noted that this will lead not just to a "freeze" but to a regression of Polish science, including the generation gap due to reduced influx of young personnel, total neglect of certain disciplines and gradual loss of Poland's position in world science heretofore gained by strenuous effort.

In science policy, distribution of available means among different types of research is important. Depending on the type of research, criteria differ, because in applied research most costs are a function of demand, while in basic research the so-called threshold value, below which a new project is doomed to failure, is crucial. For this reason, the share of basic research outlays in industrialized nations is relatively smaller than in those with medium or low technological development. Therefore, an increased proportion of basic research in R&D spending in a difficult economic situation in a country, when the demand for scientific research in industry is diminished, is a natural phenomenon that should be reckoned with in decisionmaking. At any rate, this share is small, and raising it would not affect allocations to applied research to any significant degree.

In scientific research centers, the share of basic research was as follows:

1970	12.1%
1975	12.4
1976	13.1
1978	12.1
1980	13.1

In the present situation, the necessary minimum for basic research should be 18 percent, and even a raise to 20 percent would be justified. This follows from the slow development of basic research potential and its easy deterioration under unfavorable conditions. The period of "maintenance" of science concerns above all this group of studies.

5. Communications in Science

The basic condition of proper development of science is ease and comprehensiveness of communications. This concerns free and uninterrupted communication between scientists, within a discipline or interdisciplinary, as well as interfaces between science and its social environment. This is only natural. Scientific knowledge as such constitutes the collection of verified and ordered data about the world. It can only fulfill its useful function given proper operation of the facilities effecting their transmission. Communicating (which was sometimes disregarded) is also a substantial cognitive and knowledge-creative factor. Exchange of views, experimental results and theoretical contributions are indispensable for finding the scientific truth.

Communication in science normally has one of the two following forms:
--direct: through meetings of scientists; starting from everyday contacts at work through trips to other centers to larger national and international congresses; and
--indirect: mainly through publications of books and journals, as well as through knowledge dissemination activities, by various institutions and communication means.

An important focus of communication today is systems for organizing scientific information. In the face of huge amounts of created information that may be of interest to scientists in various fields, it is necessary to collect, process and retrieve data in a selective way.

Polish scientists have been using all available means of communication. In Poland, during the past three decades, development of communication means was observed in every sphere of life. These developments, however, did not enhance the actual "exploitation of information," which occurred worldwide and manifested itself in a drastic increase in the number of journals, publishing houses, international academic presses and vast expansion and increased importance of information systems. The situation in Polish science as regards various communication forms is discussed below.

Publishing of Books and Journals

The situation of publishers and readers in Poland is alarming, as discussed in a great number of reports, and is well known to authorities and the general public. The competent agency for these matters is the recently created Council for Books, under the aegis of the Ministry of Culture. It would be unnecessary, therefore, to present the overall picture of publishing in Poland. Certain data concerning scientific books and journals, however, would be in place.

Between 1976 and 1979, there was a gradual decline of scientific publishing. The output of scientific books and academic textbooks decreased in that period: there were 0.9 percent less titles, 3.4 percent less signatures and 21.7 percent less copies. In the meantime, the number of scientists grew by 9.3 percent. This resulted in a drastic drop of titles per scientist. The absolute number of titles decreased by 99 percent to a total of 5,052.

Journal publishing was even worse off. In the years under discussion, there was a decline in journal publishing: 21.1 percent fewer titles, 22.1 percent fewer copies. By late 1980 the total number of science journal titles was 917.

In 1980, however, there was a gradual growth of the output of books and journals, with the number of book titles rising to 5807 titles and 73,213 signatures. But in 1981 further deterioration set in.

Generally, the main causes of dramatic difficulties in publishing stem from the limited production capacity of printshops and paper shortages. This resulted from years of neglect in the growth of the infrastructure, as well as passive attitudes of many individuals to science and culture.

Publishing in science has its own specific character and should be pushed to the margin of trade, academic and political publications. The reason for this is that solution of the difficulties does not hinge solely on a shortage of paper--relatively small--which is required for publishing of scientific books. Books and journals in science are a working tool and major channel for exchange of results. Most publishers use small circulations, with difficult composition, leading to a high per-copy cost. The principle of economic profitability, therefore, cannot be applied to scientific books and journals. This calls for budget subsidies, and, when deciding on the self-sufficiency of the publishing system in general--covering shortages of small circulation publishers from revenues of large circulation trade publishing houses.

To improve the current situation, relatively small investments are needed to reactivate the productive capacity of small circulation printshops that have been devastated by too longstanding exploitation and to build up the domestic base of small-scale printing. That is a cheaper way of covering these needs.

Sometimes minor changes in organization involved in printing are needed--for instance, some financial privileges for difficult types of composition.

Another aspects of the question is the policy of scientific publishers. The current campaign to review the substantial principles of published journals should be continued. But the decision criteria must be based on realistic qualities. The main principle should be representativeness of all areas in which Polish scientists have something to report in periodicals or compendia. Limited circulation should not be a cause of discrimination. We should fight against useless materials and the pressure to publish all doctoral disserta-

tions. Besides, the publication of some "scientific notebooks" is a dubious practice. Careful selection of materials submitted for publication should become a common practice.

Special care should be given to domestic publications in foreign languages, which raise the prestige of Polish science abroad and, after all, are a source of foreign currency and useful publication exchange with foreign publishers. The success of such publications, however, depends not only upon their high scientific level, but on regular periodicity, which calls for assigning them high publication priority.

Finally, one should point out the growing shortages in the distribution of books and journals and the need for reducing bureaucratic obstacles to subscriptions, particularly by foreign agencies.

Influx of Foreign Literature

Foreign exchange shortages have drastically decreased the influx of foreign literature. It has been estimated that for keeping abreast of current world science one should have access to approximately one-third of the scientific journals published in the world. Polish science has access to one-fifth, which covers its major needs. Lately, however, the ratio has been drastically reduced, and in some areas we are practically isolated from the world. Irreparable damage has been caused by interruption in subscription to journals carefully accumulated over decades. The "survival maintenance" during the period of the crisis can be made at the expense of gradual suspension of experimental research work, but getting no foreign scientific literature means retrograde development.

In this situation, a strategy must be worked out to avoid information vacuums in science. It should be established as a principle that at least one copy of each valuable book or journal be accessible to groups of scientists active in the respective areas. Effective centralized information should be organized to find out where such unique copies are kept or develop a system of readers circulation of these titles, for instance, through multiplication --made solely for internal purposes within the limits set by the Geneva Copyright Convention.

The so-called informatorium, a system under development for a number of years at the Information Center of the PAN, deserves immediate support. This system supplies to readers copies of tables of contents of selected journals and copies of selected articles from these journals. This requires, however, duplication equipment (xerox machines) on a larger scale than has been available until now. Domestic production of this equipment would certainly be justified under such conditions.

Libraries

Many of the library collections were destroyed during the Second World War, losses that are recoverable to a limited degree. It is estimated

that Polish scientific libraries have approximately 50 million library units, comparable to library resources of a city such as Paris or London. The gaps call for an even greater efficiency in management of these funds. We have highly skilled librarians, but--similar to the base of research--shortages of space and equipment are fatal and create obstacles to library usage. At a time when domestic books have become expensive and foreign books inaccessible to individuals, the importance of libraries increases as workshops of science. Organizational facilities should be provided for libraries to become centers of scientific information to a greater extent than they have been in the past.

Scientific Information

Every scientist in Poland understands the importance of library work, although relatively fewer are aware of the true meaning of information work (information centers, information services, information publishers, information banks and information systems and networks), and operate under the false impression that all these things are superfluous for true research. Failure to understand the problems of scientific information and underestimation of their importance can be observed even among those responsible for science and science policymaking.

In the meantime, in industrialized nations, large outlays (over 5 percent of total science expenditures) are spent on scientific information--including special training of all scientific workers and development of powerful centers of scientific information.

A comprehensive action in scientific information is necessary in Poland. This should include improved organization of the existing information system, wider popularization of the use of information among scientists and increased employment in the field. The existing institutions, such as the CINTE, INTE, the Information Center of the PAN, the People's Library, Wroclaw Polytechnic and branch centers should be utilized to the fullest extent. On the other hand, there should be no centralism, management by directive and gigantomania, which all lead to nonoptimal solutions. Information activity is expensive. Flexible strategies should be used, depending on specific conditions. One of the reasons why previous projects and recommendations failed has been their excessive and unrealistic scope.

Most realistic under the current conditions is a moderate decentralization and partially also participation in specialized worldwide or national systems, mainly in socialist nations, which can be based on bilateral agreements. This concept is implemented through the principle of "commodity exchange." In this way, we obtain access to reserves accumulated in the system, providing our share of well and rapidly prepared information covering Polish materials in the specialty field concerned. Processing of domestic materials will require a greater commitment by scientists themselves--the creators of primary information.

National Scientific Meetings

The process of disintegration of various groups of society currently observed in Poland is also seen within the scientific community. In view of this situation, and in the face of the fact that Poland lacks such public institutions as university campuses in the United States (which automatically facilitate informal contacts between lecturers and between lecturers and their students), all efforts of scientific centers towards organizing or intensifying domestic conferences should be supported. Centers should conduct workshops with obligatory attendance for those who have signed up for the workshops. Summer and winter institutes should be organized, ensuring the fullest possible exchange of experience between communities.

In light of the current economic reform, contacts of scientists and practical workers become essential. They are beneficial for both parties and should be continued.

Generally, in Poland, fewer professional conferences are held than in other developed nations. Such conferences are expensive, but compared with their benefits, their social cost is small. Simplifying the rules for sending delegations to such meetings is necessary. The situation with exchange of scientists between centers and training and apprenticeship exchange is poor. The first priority here is to ensure the visiting workers and trainees the possibility of housing on the basis of rotation, or all the necessary administrative arrangements involved in several-month-long business stays.

Cooperation with Foreign Countries

The need for all-around regular foreign contacts for science is obvious. In the mid-1970's such contacts in Poland were developed. A drastic reduction of funds for foreign trips and reduced possibilities for inviting visitors from abroad have changed the situation, especially after the cost of foreign stays and conference participant fees has grown. Currently, only a small fraction of such trips can be covered by the budget. This suggests general conclusions defining the foreign trip policy.

First of all, one should make use of the understanding and favorable attitude of socialist nations and enlarge the scope of bilateral and multilateral scientific exchanges with these countries. While until now the principle was to have equal numbers of weeks spent by contact parties in respective countries, now efforts should be made--especially in regard to the Soviet Union --to increase the number of visits to Poland.

As regards cooperation with capitalist nations, some 80 percent of foreign trips are partly or completely paid for by the inviting party. This has its good and bad aspects. Although it indicates the prestige of our scientists and cuts the cost of cooperation, it limits the possibility of controlling the subject areas and the selection of visitors, because invitations are usually personal.

In the current economic situation, it is hard to seek any substantial increase of financing for international cooperation. One has to be reconciled to this state of affairs. Efforts should be made, however, to secure the largest possible benefits for Polish science through individual contacts.

In view of this, it seems appropriate to support individual trips by scientists, but provided they are of a scientific value not only for the traveling scientists but for the centers with which they are affiliated as well. It is also desirable to influence the agencies from which these invitations originate, so that both selection of subjects and of invited participants would be done in a way most appropriate to us.

It seems that one cannot overestimate the chances for bilateral exchange with capitalist nations. Except for a few scientific areas, we are not a nation attractive for visiting scholars and trainees.

One should further consider the relatively numerous instances of emigration of scientists for financial reasons--mainly to lecture in developing countries. These people, however, remain strongly linked with Poland and most return home after the contract expires. They are also willing to extend minor services to their parent institutions.

A difficult question is the composition of delegations sent to major international congresses which are important for the prestige of Polish science. In the face of scarcity of means, some of these congresses deserve priority treatment, and financing of their delegations should be done on a case-by-case basis.

Currently, while capitalist countries are striving for international isolation of Poland, organizing international events in Poland becomes particularly important. Such events usually are profitable, both financially and in substance. Fees and hotel payments are made by foreigners in foreign currency, which exceeds the cost incurred, and a good organization of a congress or symposium raises the prestige of the scientific exchange. Organization of congresses, however, should be streamlined by decentralizing the activities of "Orbis" with a reduction of its overall costs.

Popularization of Science

Individual work by scientists and institutional activities of scientific societies and other organizations are important in this area.

Regional and professional societies of scientists and scientific societies grouped within the framework of the Main Technical Organization, as well as scientific professional societies (such as physicians' associations), carry a vast public potential. During a period of reforms aimed at overcoming profound social, political, moral and economic crises, new prospects for development and chances for effective utilization of their potential are presented to these societies. As public self-governing organizations of

Polish science, joining together almost a half million representatives of scientific disciplines and practical experts on a national scale, as well as organizations bringing together members of different professions and integrating the science community on a regional scale, these societies are less susceptible to bureaucratic flaws and must consolidate their activities to implement their statutory tasks. This concerns development and advancement of scientific standards. The Council of Scientific Societies, as the common organ for these associations, and the Presidium of the Academy, have a definite, important part to play in the accomplishment of their tasks.

Continuing support by the authorities to these societies is justified and should not be reduced. Other forms of dissemination of scientific knowledge, such as the People's University of the PAN and associations for general knowledge, are also important. Here we just mention these aspects which largely fall within the competence of educational and cultural activities.

6. Use of Research Results by the National Economy

In the preceding sections of the report, the focus of discussion was mainly aimed at the development of science itself and its social and economic effects. Here we present the aspects of organization of basic research in a most comprehensive way, viewed from the standpoint of recipients of research results mainly in the industrial sector. This different perspective makes certain repetition unavoidable, as it is required for presenting the problem from different angles essential for practice.

Nor is it possible to avoid certain simplifications. It seems in particular worthwhile to concentrate attention on the analysis of negative factors as a basis for drawing general conclusions. General critical statements, which apply to a large proportion of research centers and industrial enterprises, do not abolish the fact that in many ministerial institutes and higher schools there was a perfectly organization cooperation with industry, so that the results of research were immediately transferred to design and process bureaus for implementation.

In the 1970's, the growth of the national scientific potential and research and development facilities of the industrial sector as well as the capital investment dynamics created, in principle, a possibility for drastic change in the technological level of the polish economy. In practice, however, such change took place mainly through imported technical knowledge. Purchase of licenses was accompanied by large participation of imported machines and equipment in industry, which burdened the trade balance of the national economy. Export of technological results during the entire postwar period did not compensate for this; 97 technological solutions covered by 144 licenses were sold abroad. Of these 97, some 60 percent came from research and development facilities and the rest from industry. Even compared with other socialist nations, the export of technological ideas is incommensurably small for the available potential.

The innovation level of domestic industry, agriculture and other economic sectors evolved mainly through introduction of package licenses that were purchased (with a large share of imported equipment), rather than through introduction of domestic scientific and technological thinking. The gap in research and technology between Poland and industrialized nations existing in some areas was not the unique cause of insufficient participation of domestic research and development potential in innovative processes, however.

The main reason for the low level of introduction of the results of considerable research and development potential was the system of operation of the economy coupled with the absence of cohesion between scientific, technological and economic provinces.

The results of operation of the system of orders-distribution existing until now can be described with great simplicity as follows: With the decline of economic self-management of subordinated organizations, decisionmaking (including innovation decisions) was done without proper knowledge of the local technical and economic conditions, leading to inevitable growth of incorrect decisions. The hierarchical structures of management and lack of self-management of enterprises limited the possible choices of rational technical solutions. As a result, on a national economic scale, production potential was underutilized. The high degree of investment further deepened this process, while forceful growth of the fixed asset potential blocked domestic investment, as it was based on license packages damaging the balance of payments.

Neglect for the essence and specifics of the progress of science and innovation processes and a voluntaristic transfer of unverified principles of centralized economic management of the sphere of science and technological progress disintegrated the science-technology-industry (S-T-I) cycle in Poland, leading to a growth of the tendency toward independent development of individual phases of this cycle, i.e., science research facilities and production.

The first phase of creation of an innovation--the sphere of science--is represented by higher schools and institutes of the PAN independently and separately from practical activity, as they have their own financial support system, peculiar mechanisms of creation and acquisition of information, and, finally, and importantly, an independent evaluation system for advance of academic degrees and titles serving as an indicator.

The orders-distribution system is incapable of determining the abovementioned mechanisms completely. The result is that the sphere of science was not organically conjugated with the needs of the economy (except for personnel development and some of the applied research conducted as desired by the authorities). Even during periods of strongest pressure for forming research programs "to meet the needs of the economy," it was largely responsible for the phenomenon of "invented predictions" made in the scientific community, in keeping with the nature of a research project

as a basis for soliciting more funds. The phenomenon was not unique to Poland. For example, instances of this were observed in the projects of the National Science Foundation in the United States since the late 1960's.

In the second phase of the innovation cycle, ministerial institutes and research and development centers become functional; these are the so-called research and development facilities. These facilities were largely created to meet the demands of developing industries.

Despite their industrial roots, the ministerial institutes were largely patterned as conventional scientific centers, managed in a similar way, and acquired a scientific status aimed at raising the prestige of their staff. The financing system was such as to ensure their serving the needs of the economy and integration of facilities with production. The concept, however, did not live up to expectations. Even the application effects, conceived as a tool for linking research and development units and industry, failed to stop this independent development, which was also promoted by the adoption of the principle of qualification from the academic community, creating motivation for outstanding designers and technologists to seek academic degrees and titles at the expense of their qualities as engineers.

The third independent phase is the sphere of production. Management of enterprises by directives, evaluation of their effects by indicators of output and sales, subordination of activity to wage and employment allotments resulted in orientations toward planned targets which were not determined by innovative processes. An enterprise was motivated by plan fulfillment; this brought means which, in turn, gave a head start for plan fulfillment. Stimuli in the industry were thus unidirectional. In contrast, innovations threatened to push the enterprise out of its rhythmic plan fulfillment.

A consequence was disintegration of the development cycle. Management tools such as planning and financing, instead of integrating, only strengthened the mechanism of separate evolution of the individual phases of the cycle.

Planning, which must perform an integrative function and ensure a flow of ideas from science to practical application, worked as a disintegrative influence, strengthening the tendency towards independent functioning of individual institutions and phases of the S-T-I cycle. This was due to several factors discussed below.

Although long-term plans are essential for research and development, annual and five-year plans prevailed in this area, as was the case in industry and the remainder of the economy. The plans of research work, technological progress and industry were not integrated, nor were they even correlated. This lack of cohesion between sections of the plan strengthened the independent treatment of goals and activities of the subjects of the innovative process, especially since failure to understand local conditions led to setting of plan priorities mainly by party authorities in terms of hierarchical-structure goals, which differed from the goals motivating the activities of scientists and workers' collectives in the individual phases of the cycle.

The deterministic quality of the plan serving to provide for unexpected eventualities, or even to estimate the feasibility of goals, paralyzed the initiative and audacity that are necessary for creative work. A consequence was a minimalistic attitude--that is, sham work--which further deepened the disintegration and increased opportunities for research projects and technological developments inessential for practical application.

Predominance of current production plans, lack of experience in market analysis (predominance of producer's market), led to a situation where planning for development needs took place with insufficient information and lack of skills in defining assignments for the research and development sphere. Institutions in science and industrial research facilities planned their research problems independent of the industrial sector.

The choice of research projects was subordinated to goals of the institution, ensuring its reason for existence, while the pressure for meeting so-called "industrial needs" was satisfied by minor projects or technical services. In this situation, independent evolution and movement around the institution's own goals were emphasized. Expressions of this were the turn to basic research or superficial pragmatic justifications for theories.

Because of better pay and existing procedures that allowed relatively easier scientific careers, the system of values of the academic community became institutionalized in research and development. This suppressed the goals of the engineering community, where development of designs and processes and their effective application should have the highest value.

We have deemed it necessary to discuss the situation at some length in this report, because the scientific community is not quite familiar with it. It must be reemphasized that this description involves certain simplifications and that a great number of research centers and industrial enterprises differ from these descriptions in a positive sense.

Conditions for Improvement of Application of the Results of Research and Development through Economic Reform

The concept of reform includes provisions for the following economic tools to become the basic instruments for centralized action:

--income taxes;
--creation of enterprise funds;
--taxation of production sectors.

Instruments of direct action will be:

--information on goals;
--contracts and contract obligations;
--concessions and orders;
--guarantees of credit; and
--norms and qualitative requirements.

The units of the research and development facilities at the parent enterprise are to be financially self-sufficient and self-managing entities.

An important economic tool for creation of conditions for innovations in the economy will be provided by the possibility of setting up and dismantling research and development units (as well as enterprises) by the founding agencies.

A large proportion of research and development will be performed by enterprises at their own cost. Strategically important (for the development of science and the economy) research goals will be funded centrally.

In the organizational structure of central agencies, there are provisions for the enhanced role of general economic ministries (such as the ministries of finance, labor, wages and social matters) and such institutions as the State Price Commission and banks, in their capacity as headquarters of activities and sources of guidance; the Planning Commission will have only strategic functions.

Assuming that the economic reform will favor abolition of the government management of research in industry through orders, allocations, limitations and imposed price indices, mechanisms that will generate progress will develop in the spheres of production, science and technology. In this situation, the Committee on Technological Progress (discussed in section I.1) will acquire the functions of headquarters, performing solely strategic functions and largely operating as an initiator in innovation and application of inventions and research results. The Committee on Technological Progress would work jointly with technical associations that are members of the Main Technical Organization and other associations as the PTE and TNOiK. They could have a moral influence on the effective implementation of technological progress and offer useful judgment concerning the directions of technological progress. Transfer of scientific and technical knowledge, and especially licensing policy, on a national scale should become a major subject of concern for the committee, requiring nationwide coordination as a major element of economic development.

The operation scope of the Council of the Fund for Technological Progress would be much more restricted than that of councils or committees for matters of science and technology or ministries of research and technology existing in many socialist and capitalist countries and the Third World. The Committees for Science and Technology in socialist countries perform too many functions of direct administration. In the Polish system, these functions would be minimized by the reform. As a result, the headquarters functions, based on science studies or technology studies, will find their proper place. Not only the scientific community, but engineers as well can and should organize, within the framework of self-management, formulation of their opinions concerning the directions of development, and programs and problems of research.

Proceeding from its own opinions, the council should be concerned with promoting a climate conducive to technical creativity. It should organize activities, preparing strategic investment decisions. Its functions should include solution of problems in the choice of priority areas in technology, since these depend on the economic, social and political factors which lie beyond the sphere of science. A nation the size of Poland cannot expect to advance a broad front of research, but should rather effectively participate in international competition to come ahead in certain areas. Correct designation of what is in the forefront of research is thus essential.

If enterprises and research and development units function on the basis of economic principles, the centralized management of current operation programs will be reduced. The purchase and sale of innovative projects will become a natural need, and conditions for marketing will follow from the trade agreements and not just institutional descriptions. The central government, through taxes and interest rates, can certainly modify these conditions, but will not be able to impose them. The distribution of profits from sale and application will be defined by statutory principles of operation of research and development units.

It seems likely that in the initial years after the reform, before the domestic market for scientific and technological knowledge becomes established, the financial situation of the existing research and development centers will be dramatic, many running the risk of bankruptcy. In higher schools, this bankruptcy already threatens contract-based projects, or the so-called support enterprises. It seems that an intervention fund should be established that would develop recommendations to help maintain the normal activity of centers or units with a large research potential for retaining their position in science and technology.

In general, the geographic distribution of financing sources will be changed through decentralization of a major portion of funds allocated to science and development, leading to easier, more efficient conditions for centralized financing, which is necessary where the sphere of activity is indispensable for technological progress. As in industrial enterprises, where the function of banks will grow, in research activities and dissemination of innovative processes, banks will come to play a greater role. Foreign exchange and domestic credits must become tools for self-correction of the instruments of control.

The conditions of the operation of the national economy will create chances for innovative enterprises. The central agencies will inspire the creation of so-called "guaranteed risk" organizations. In a general outline, this will include:
--organizational and financial support to individual inventors who do not fit into the framework of mass production and the main interests of enterprises;
--creation of small firms on the initiative of research and development workers that will be temporarily disengaged from the mainstream of activities for larger enterprises; and

--in the structures of higher schools and the PAN, incentives should be created for establishing small organizations to carry on research and development of a likely future significance--to be organizationally and financially supported by the larger enterprises.

All these changes are closely linked with labor policy. It seems that they should provide favorable conditions for migration of personnel among spheres. This is a principle likely to counteract the present disintegration of science and technological progress.

Conclusions

The report presents the results of comprehensive analysis and deliberations conducted among groups of scientists and practical workers, as well as synthetic suggestions flowing from the expert reports prepared by departments of the PAN.

The report presents a diversified picture of Polish science, which is credited for a number of accomplishments of worldwide importance, and at the same time does not always live to the expectations of the economy and society.

Science and the community of researchers creating it, while performing their cognitive educational, culture-creative, innovational and expertise functions, to the extent afforded by their resources and means, are incapable either of forcing enterprises to undertake innovative production processes, or of changing the social conditions (or at least ensuring that the results of research and expert studies be taken into consideration when conducting the activities of a crucial importance for the nation or region, or an area of economic practice).

The hopes that science (and particularly science in medium-size country like Poland) have failsafe prescriptions for all problems and economic and public difficulties are unjustified. On the other hand, science should be viewed as an organic component of the nation's life.

In the last few years, development of science in Poland, despite its complicated nature, had the following characteristic features:

(a) The term "science" was used in too broad a sense, with far-reaching consequences not only in the method of presentation of the potential of science, but also in extending to development centers the evaluation and promotion criteria that are proper for academic institutions; the prestige of science has been repeatedly abused to give credence to dubious, poorly justified or totally wrong propositions;

(b) The cadre of scientists in Poland is relatively numerous and well-educated and bears a strong intellectual potential that could be better utilized for the benefit of the nation and the progress of science itself; this principle retains validity despite the observed devaluation of the profession of scientist discernible especially in some humanitarian disciplines;

(c) The material base of science is too weak, leading to the mainly extensive nature of experimental research and--consequently--its poor effectiveness;

(d) The organizational system of science has been changed repeatedly; it is still incoherent and bureaucracy-ridden; administrative management by directive still prevails over creation of motivations for work;

(e) The system of product-type financing has basically proved valid, but was used too broadly and inaccurately; as a result, it has become enveloped with bureaucracy;

(f) The system of applications has been ineffectual for decades and does not provide sufficient stimulation for applied research and development; the obstacles came both from science and practice, and the late 1970's witnessed continuing deterioration;

(g) The pressure experienced by the social sciences led both to poorer quality results and lower levels of scientific personnel in these areas.

The report characterizes this situation in more detail and proposes actions aimed at overcoming, or at least reducing, some of the difficulties. This concerns aspects within the scope of science and the scientific community, as well as those under the competence of decisionmakers in charge of formulation of science policy.

The point of departure for the activities is at a strategy for scientific research, as well as the choice of directions for research and appropriate degrees of concentration. It is proposed that the entire field of science be covered by a "thin layer" of financing, so as to ensure at least minimal continuation of scientific research. At the same time, a relatively small number of problem areas should be given priority treatment. For these areas, financial means necessary for retaining our world position in science and obtaining the desired practical effects should be provided. During the period of crisis, a sound intellectual potential of the entire range of Polish science should maintained, which involves, among other things, ensuring proper conditions of work for outstanding schools of Polish science.

From notions of a global strategy of scientific research, the choice of priorities in individual scientific disciplines and fields and subsequently choices of problem and priority areas and projects is derived. Pertinent analyses are contained in expert reports prepared by departments of the PAN. This report advances a concept of establishing major comprehsnive programs. In each of the groups of scientific disciplines,the report outlines the problem areas that should be given top priority because of their cognitive value and practical importance.

A crucial instrument for implementing this strategy is the system of financing of research, for material incentives should, to a large extent, replace the current system of centralized management.

Three basic routes for research are proposed:

(a) Product-based financing, to be concentrated more than at present on carefully selected cognitive and practical subject areas. It should provide a guarantee for completion of projects and cover a period necessary for the entire process. The source of financing in basic research and partly applied research should be the state budget (until now the fund for research work), and for the remaining part of applied research and development work, a centrally distributed fund derived from taxes and other forms of levies on enterprises.

(b) The organizational-unit financing method for a scientific center mainly refers to higher schools and PAN centers concerned with research in individual scientific disciplines or fields of study. This financing comes from the budget and is managed mainly by the PAN and the Ministry of Science, Higher Schools and Technology.

(c) Order-based financing is conducted through contracts concluded by enterprises, other economic organizations and scientific centers. This is the principle of self-financing, which mainly applies to centers of research facilities in the industry. However, this does not have to be the only form of financing for these facilities. It should be supplemented by organization-unit financing that could provide for such major research programs that go beyond the interests of the parent enterprise and are of a long-term nature. Introduction of the principle of self-financing for research centers concerned mainly with development work (research and development centers, experimental entities and central laboratories) calls for closer organizational links between these units and enterprise. Transferring a large number of these units from the group of "scientific research entities" into the sphere of enterprise development facilities, and even incorporation of some of them into industrial enterprises is desirable. This restructuring of the R&D sphere will provide for proper proportions in the group research and development units overinflated in the mid-1970's.

In view of financial limitations and especially the shortage of foreign exchange, when undertaking new research programs, the criteria of social and economic need should be, in the few coming years, supplemented by the criterion based on whether the group of workers concerned possess the required equipment, material and personnel to avoid starting projects that lack adequate means for completion.

The system of product-type financing would be based on creation of two councils on the national level that would manage the respective funds: the Council of the Fund for Basic Research and the Committee on Technological Progress. The former would operate with the support of the Polish Academy of Science and its scientific committees. The Committee on Technological Progress would have a collective organ in the form of a Council on Technological Progress. Both institutions would provide coordination in their respective spheres. Key decisions on scientific and technological policy would be made by the Committee of the Council of Ministers, chaired by a deputy prime minister.

In the area of personnel policy, efforts should be made towards an influx of young cadre, indispensable for maintaining the proper age structure of research centers and for surmounting the barriers between organizational spheres through easier circulation of personnel while maintaining the specifics of personnel selection in each of the three spheres.

In the face of the limited growth in employment, the possibility for the influx into science of younger researchers should be connected with sorting out workers that fail to attain adequate results. This process could be provided with an objective basis by developing and introducing a system of periodic evaluations of scientific research workers.

Simplifications in the system of scientific degrees and titles is desirable. For instance, limiting to one title two currently existing titles of professor and broader possibilities for awarding the degree of doctor habilitatus based on a publication of scientific contributions instead of a special habilitation thesis.

Providing conditions for revival of creative scientific criticism and development of public evaluation of research results calls for lifting the limits to free scientific expression and decisively improving the facilities for circulation of scientific information, both in the form of accessible publications and through small-run publications for a limited circle of recipients concerned with the particular subject areas.

Development of science especially in a situation of shortage of means calls for intensifying all forms of international cooperation. Special attention should therefore be given to the fact that limiting the influx of scientific publications from abroad, which is the least expensive, although most passive, way of maintaining contacts with world science, threatens consequences that would be difficult to overcome.

There is a justified need for developing in Poland science projects and centers working in this area. The complex social and economic organism of modern science requires a basic knowledge and thorough analysis of the processes evolving in this sphere. It is only on such a basis that one would be able to manage in a rational--and not voluntaristic--manner the organism of science.

The report does not pretend to exhaust all issues involved in development of scientific research in Poland. We only tried to maintain a hierarchy in the selection of most essential aspects. Scientific research is certainly not an isolated system. It is affected by a series of determining factors which reflect the overall situation in the country, as well as by the decisive factors of science policy. The report, therefore, leaves some questions open and sometimes offers alternative solutions without stating a preference.

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DEVELOPMENT OF MICROELECTRONICS, MICROPROCESSORS OUTLINED

Production of First Microprocessor System

Warsaw ZYCIE WARSZAWY in Polish 12-13 Mar 83 p 3

[Article by Bozena Kastory: "Microprocessor in Polish"]

[Text] "Poland will not produce microprocessors," said Professor Dr. Adam Schaff in an interview with ZYCIE WARSZAWY entitled "Progress Towards Obsolescence" (24 Jan 1983).

Just a few days later, I learned that Poland in fact has started to manufacture microprocessors. "In December 1982 the first Polish microprocessor system was put into production at the TEWA factory, and it's not under a license. The doubtful are invited to place orders," reads an excerpt from a letter received by me from Professor Dr. Habilitatus Eng. Cezare Ambroziak, director of the Institute of Electronic Technology of CEMI.

Professor Adam Schaff's opinion concerning Poland's electronics stirred emotions. Electronic technicians,managers and computer scientists responded. It had in fact been known for some time that the gap between Poland's and the world's microelectronics was widening. We have plenty of skilled electronic technicians, physicists and mathematicians--but we lack the proper facilities for design of electronic systems, funds for purchasing and often have no coherent and far-sighted program.

Professor Dr. Adam Schaff, a member of the Club of Rome and co-author of the report "Microelectronics and Society," issued by an international society of scientists, stated, among other things:

"As regards microelectronics and its industrial introduction, we are an underdeveloped nation. In the West, the lag of socialist nations in this respect is estimated at 10 to 15 years."

Answering a question, he said: "What is going to happen to the countries where microelectronics is still in its infancy?"--"We will sink to the rank of the Fifth World countries. The Third and Fourth World countries

are being helped, but the Fifth World countries will not be helped by anybody. What is the root of the disaster? Above all, it resides in the fact that even if we develop industry--towards the end of the century it will only be fit for a museum of antiques. This is the problem of industrial competitiveness. There is no such cheap labor that could compete with the microprocessor."

And further--"Today's Poland will not begin to produce microprocessors. Such wealthy states as the FRG do not do that either, not even under an American license. There are two nations in the world--the United States and Japan--which hold 95 percent of the world market, and others work under their licenses. This is an extremely expensive and capital-intensive industry."

A few days after the publication of this interview with Professor Schaff, I received the above-mentioned letter from the Institute of Electronic Technology:

"Professor Schaff's opinion that Poland today will not start production of microprocessors ... unless under an American license, was in fact voiced shortly after the Institute of Electronic Technology, CEMI, in Warsaw completed the development and forwarded for production at the TEWA factory in December 1982 one of the world's most modern central elements of a microprocessor system.... We thus do have the first Polish microprocessor system."

The writer of the letter, Professor Dr. Cezary Ambroziak, is a well-known figure in world electronics. When, in 1968, the 20th anniversary of transistors was celebrated in the United States, the professional journal ELECTRONICS published a background paper on semiconductor studies, saying that only three Europeans had contributed to the development of microelectronics, and especially integrated circuits. One of these is Professor Cezary Ambroziak, who was among the first in the world to construct an integrated circuit.

Professor Ambroziak now informs us that we have the first Polish microprocessor without a foreign license.

What is a microprocessor? It is an equipment unit so small that a dozen microprocessors will fit on the palm of a hand. It appears as a golden square plate immersed in a slightly larger elongated rectangle.

Less than 20 years ago, I remember watching with pious concentration in the Palace of Culture the first computer imported for the needs of the computing center of the Polish Academy of Science.

It was not only as large as oven, as they say, but rather as several large ovens, and worked with such a noise that one couldn't hear one's own words. I remember how it made the walls and the floor vibrate. The

microprocessor, called fondly a "chip," is faster than that machine, has a larger memory capacity and can be mounted practically anywhere. This electronic chip even today affects the professional and personal live of millions of people on the surface of the earth and beyond. It can be "sticked" into everything. Into satellites, ships and machine tools. Into motor cars. It is the heart of a home computer. It recognizes the owner and opens the door only to him, controls the refining of crude oil and reprocessing of nuclear fuel. Built into voice synthesizers, it speaks several languages, teaches children, plays chess (instead of a human partner) and selects information from electronic libraries, newspapers and books. The list can be continued. For instance, it designs industrial processes, simulates trial and error procedures, gives life to automatic machinery, distinguishes colors, adds and multiplies.

Is it indispensable?

Recently Polish ships were banned from entering major ports without proper electronic anticollision systems. These systems must be built into the ships. The Japanese evaluate the difficulty of this project as equal to building a giant ocean liner of 100,000 tons displacement.

In the Polish situation one should also consider the embargo, which affects all the most modern electronic designs originating from Western countries.

The Polish microprocessor does not belong to the generation of equipment currently developed by the Americans and Japanese; however, it is the most common type in the world, a sort of a standard class car which seats five and can make 100 km per hour.

Professor Dr. Jaroslaw Swiderski from the Research and Production Semiconductor Center speaks about efforts to introduce microprocessors into industrial production as a battle conducted on several fronts. One front is the general scarcity and lack of means. The other front lies in the sphere of convictions. "Many people here believe," says Professor Swiderski, "that if we don't have spades we can also do without microprocessors. Our mechanics believe that if we made spades on such perfect machine tools as those we have at the Semiconductor Research and Production Center we would make more profits than with microprocessors. Farmers are waiting for tools. So we would have bread and money."

Nor is the market prepared to receive microprocessors. Industry has never absorbed and still does not absorb what science offers. One has to advertise and explain what can be done with it. How is this done? Professor Ambroziak explains: "We have placed them in the technical press with no effect. Our engineers went to production enterprises and held meetings with designers, who were amazed to learn that microprocessors and other large-sacle integrated circuits are produced in Poland. It was only ads in newspapers, however, that led to a depletion of our inventories. We have sold 200,000 integrated circuits in two weeks. The buyers are institutes of the Polish Academy of Science and large industrial enterprises.

At the Passenger Car Factory, they plan to use the chip for ignition control in large Fiat cars. The Central Machine Tool Design Bureau in Pruszkow will install it in control and measurement equipment. In the power industry, microprocessors could control the generators, as well as power consumption in power grids.

The microprocessor alone is not enough. It is like a brain in a glass jar--without hands and feet, and without the nervous system necessary to control the rest of the body. To be able to reduce the fuel consumption in a car, for instance, the microprocessor should be combined with an engine that lends itself to control. In the Soviet Union, they are developing a tractor that will till a large field without an operator. A standard tractor with a microprocessor will not be enough here either. Equipment is necessary which can link computer capacity to mechanical operation--be it a ship, a car, a tractor or a machine tool.

Without this, the microprocessor will remain just a strange plate that one can hold in one's hand, fascinated by its powers which now serve nobody. In a context of technological idleness, the microprocessor has no meaning. Only when it is inscribed into production will it be able to pull the stranded car from the quagmire.

At this point, the production of microprocessors is moving along, "but the equipment with which we work and must exploit intensely," warns Professor Swiderski, "will not last long. One-third of the facilities have been amortized already. They could be saved if spare components were available. Some of these we make ourselves. But this is vandalism. These spare parts can destroy equipment that is much more valuable than they are. Without it, we will be helpless--large-scale integration circuits cannot be designed 'by hand.' A computerized design system is necessary. We want to produce a million integrated circuits of large-scale integration annually. A year ago, the breakdown of basic and auxiliary production facilities happened once a month--now it occurs twice a week."

If the right tendency prevails and even in these difficult times we maintain a certain minimum capacity, at least develop the family of microprocessors, several years from now we will have a base to reconstruct electronics and raise it to the world level.

So far designers and process engineers in the industry are still learning about the useful applications of microprocessors. In several years, this ignorance, as warned Professor Adam Schaff, will be damaging, and our products, manufactured without microprocessors, will no longer be competitive, as they will be of a poorer quality, less efficient, consuming more fuel or electricity.

The Polish microprocessor, even though Professor Schaff did not expect it to appear so soon, is a good illustration of his concept of the situation in Polish microelectronics. We are capable of remaining in the club of First or Second World nations and do not have to fall behind. We have

capable people who can work, but they do so spending huge efforts in overcoming barriers. The microprocessor alone produced in small amounts, without proper facilities, does not make a summer. It must be inscribed into our general economic development.

Microelectronics, Microprocesor Industry

Warsaw TRYBUNA LUDU in Polish 28 Feb 83 p 4

[An interview with deputy director of Semiconductor Research and Production Center CEMI, engineer Stanislaw Goledzinowski, and learned secretary of the Institute of Electronic Technology, affiliated with the CEMI, Professor Jaroslaw Swiderski, by Andrzej Konieczny: "Behind the Scenes of Microelectronics"]

> [Text] The article "Electronics Without Dogma" (TRYBUNA LUDU, 27 Dec 1982) has evoked a response from specialists in the industry. Some of the public attitudes about problems addressed in that article--particularly as regards the efficient progress of Polish electronics--are expressed for our paper by deputy director of the Semiconductor Research and Production Center of the CEMI, engineer Stanislaw Goledzinowski, and learned secretary of the Institute of Electronic Technology, affiliated with the CEMI, Professor Jaroslaw Swiderski.

[Question] As a topic of our conversation, I suggest giving the latest news on the state of introduction of the first Polish microprocessor into industry, which is a functional counterpart of Intel 8080A, developed in the United States seven years ago.

[Answer] First of all, it should be pointed out that what is currently designated a microprocessor in this case is a whole family of subassemblies consisting of 11 integrated circuits including--like in a computer system--the so-called central unit, the memory, the input and output devices, etc. Some of those subassemblies had already been produced by us earlier. The latest were introduced into production only last December. This is, however, as yet only at the stage of laboratory experimental production. But, before the end of the year, we expect an industrial production line of large-scale integration circuits, which will include microprocessors, to attain complete capacity estimated at some 1 million subassemblies annually.

One can also add that Intel 8080A is the most common microprocessor in the world. At any rate, it is the microprocessor that is most suitable for our domestic needs and which is enjoying the highest demand in socialist countries.It really is a general-purpose system.

[Question] What is the basis for evaluating domestic demand for this microprocessor?

[Answer] When preparing for its production, we conducted a sort of poll to estimate the needs of various centers and economic organizations across the nation. As a result, for instance, purchasing orders have been received from numerous Mera enterprises producing measurement and control instruments and information hardware; the Predom factory, which planned to use the microprocessor for electronic control of their automatic washing machines, refrigerators, kitchen robots and ovens; as well as Telkom factories, producing telephone equipment and telephone exchange facilities; machine tool factories; scale manufacturers; and others.

[Question] All this was before the crisis, or at least before the reform, which forces the producers to be more accurate with their calculations. Will they now maintain the level of demand anticipated then?

[Answer] Mera factories in 1980 ordered from us 400,000 memory units of the Intel family, and later purchased less than 15,000 units.... However, we do not fear any major shortage of demand for our microprocessors. This may happen in the initial period, but not in the long range.

[Question] But why are you so confident? Have not there been complaints that these subassemblies are relatively expensive compared to foreign units?

[Answer] However that may be, these are probably the only products in our country which have systematically become cheaper every year rather than rise in price....

[Question] ... But abroad the prices drop 27 percent annually and sometimes more than 50 percent, in Poland the decline hardly attained 8 percent per year. As a result, electronic applications in various products cost much more in our country.

[Answer] Yet without electronic applications in a great number of Polish-made products we cannot dream of continuing their export. Some of the buyers of products of the Radom Telephone Factory, such as Argentina, already require that at least a portion of equipment units be furnished with electronic controls. These demands will not be posed only by the West. In CEMA nations, it has already been decided that in the coming years some 50 percent of telephones and telephone exchange facility equipment circulating in trade between our countries should be provided with electronic controls. The same concerns equipment for sea radio navigation, metal processing tools, machine tools, etc.

In brief, development of microelectronics is imperative for us unless we want to see our economy deteriorate to the status of Third or even Fourth World nations.

[Question] But the same fate will happen to us also if we develop microelectronics and export of electronic controlled products at any price, disregarding costs, falling below reasonable profitability limits. Why is it that electronics, which is distinguished for its productivity among other industries worldwide, has below-average productivity in our country?

[Answer] This is caused by a variety of factors: organization of this industry nationwide, the policy of its development, the scale of production, the size of the markets, the level of technology attained, etc. We are not speaking here about electronics in general but about the industry of semiconductor subassemblies, microelectronics.

World estimates show that a dollar's output in microelectronics industry is achieved after one dollar's worth of research and development in application work. As a result, even in capitalist countries development of this industry requires additional influx of external funds.

The development of the production of subassemblies there receives additional financing from producers of end products--either consumer electronic equipment or so-called professional equipment. Sometimes a source of these additional funds is government contracts, which are a form of government support for development of domestic industry.

[Question] By contrast, in our country, instead of integrating the electronic production divided between different branches of industry, it was decided several years ago to further break it down between household and electronic production. As a result, the production of subassemblies is now forced to ask the government for subsidies for further development....

[Answer] The word "subsidies," which one most often hears in current discussions, is most unfortunate, because it may produce the impression that one is talking about an enterprise artificially supported by the government which would otherwise go bankrupt. In reality, however, our--that is, the CEMI's--financial situation would appear totally different if we could use, for our technological development, at least the money earned for this purpose at our enterprises in the form of allowances into the Fund for Technological and Economic Progress.

Last year, which, incidentally, was for us a year of record research achievements, we forwarded for industrial application 40 new projects. The introduction of these results required an outlay of 380 million zlotys. From allowances to the Fund for Technological and Economic Progress, we accumulated a large sum of 260 million zlotys. However, according to the currently binding regulations, we were forced to transfer half of that amount to the central fund....

[Question] ... And eventually you could ask the administrators of the fund to subsidize you from your own money?

[Answer] We received nothing, so that this year our requirements have risen to 400 million zlotys, and from the fund we were given 209 million zlotys.

[Question] What is the average scale of production of microelectronic subassemblies in the West?

[Answer] On average, a typical production line has an annual output capacity of 15 million units of this type.

[Question] What minimum size of production series is believed to be profitable?

[Answer] A series of 100,000 units, provided the time of production spans a relatively short period so that the unit does not become obsolete, which abroad means a period of 2 to 3 years, and in our country not more than 5 years. Such production with us amounts to some 70 percent of the nomenclature of integrated circuits with a high degree of integration, with the remaining units produced on an even smaller scale.

However, the small size of production series is not the only cause for the relatively higher cost of our subassemblies compared to their foreign counterparts. To the claims that it would be cheaper to import the subassemblies from abroad for dollars (acquired by Pewex), one can answer that it would also be more profitable for us to use dollars to buy gold that we need for production abroad instead of from the government....

The most important point here is that even if we had dollars we would not be able to buy most of the integrated circuits anywhere. Development of the microelectronics industry is therefore--let us repeat that once more--simply a must for the nation.

[Question] Regretting that this imperative is hard to express in terms more understandable to the public, thank you for the interview.

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